Environmental Quality Characterization for Hodgson Brook in Portsmouth, New Hampshire

A Final Report to
The New Hampshire Department of Environmental Services and
The Advocates for the North Mill Pond

Submitted by

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August, 2003

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Executive Summary

The *Environmental Quality Characterization for Hodgson Brook* presents a comprehensive review of the existing environmental data and information and identifies pollution sources and impacts. The Hodgson Brook Local Advisory Committee will use the report to make decisions about restoration and protection strategies. The report findings show that the mouth of the Brook has elevated pollution concentrations following runoff events and, in addition, bacteria levels are elevated during both base and storm flows. The findings for the upper watershed which is situated in the former Pease Air Force Base suggest that past toxic chemical contamination is no longer widespread or measured at elevated levels, possibly as a result of cleanup efforts. While the data are limited for the Hodgson Brook watershed, there have been numerous studies conducted on its receiving water, North Mill Pond, where evidence of past and/or ongoing pollution is clearly evident. A better understanding of the impacts of human activities and alterations on the environmental quality of the Hodgson Brook watershed is a critical need. In addition, the impact of pollution in the watershed on the tidal receiving waters also needs to be better defined.

The quality of Hodgson Brook water, sediment and stream integrity is threatened by both historical pollution and on-going watershed development, including the conversion of the former US Air Force Base into the Pease International Tradeport. The urbanized watershed has a relatively high coverage of impervious surfaces, estimated to be 32% of the total watershed. As expected, runoff contributes to increased bacterial and nutrient loading during and following storm events. Monitoring programs with sampling locations at the Tradeport and the mouth of Hodgson Brook have shown storm water runoff, dry weather discharges from storm drains, and movement of sediment from disturbed sites to surface waters to be main contributors of pollutants. While many regulatory programs are in place, violations of law especially rules addressing dumping and construction sites, are frequently violated.

Environmental managers should set priorities for actions to deal with storm runoff, illicit discharges from storm drains, and unstable soils on developing sites. Managers are challenged with slowing the degradation caused by current and future activities related to an urban environment and remediating the damages caused by past activities in the watershed. Enforcement of environmental laws could reduce the damage that existing laws were put in place to protect. Voluntary efforts could also reduce the negative impacts of commercial and residential activities.

Researchers have reported that sampling data from the mouth of Hodgson Brook and North Mill Pond reveal varied and ubiquitous sources of fecal-borne microbial pollution. It has also been reported that storm flows are significantly greater than dry weather flows at the mouth of the Brook and the bacterial loading during a storm increased more than 36 times compared to dry weather loading.

Information and data on toxic chemical contamination are only available for the Pease International Tradeport portion of the watershed. While most contaminants in sediments

and surface waters are below state standards, exceedances still occur. The Department of Defense Installation Restoration Program identified potential human and ecological health contaminants at the former Pease Air Force Base. Neither of the sites of concern, Grafton and Newfields ditches, were found to have human health risks associated with them, although ecological risks were found for both ditches. The Agency for Toxic Substances and Disease Registry (ATSDR) sampled both sites for contaminants associated with public health hazards. According to the EPA Hazardous Substance criteria, all contaminants were found to be below levels of concern for health risk. Since no exposure is occurring, ATSDR declared Grafton and Newfields ditches not to be a public health hazard.

Information about nutrient loading in the Hodgson Brook watershed is only available for the mouth of Hodgson Brook and the North Mill Pond. Ammonium, nitrate and dissolved inorganic nitrogen concentrations were found to decrease from sites along a transect that started at Hodgson Brook upstream of Bartlett Street and continue out to the Piscataqua River. Average loading rates for nitrate, ammonium and phosphate were all 2-3x higher at the mouth of Hodgson Brook compared to other sites in the area.

The type of information and data available about sediment erosion in the Hodgson Brook watershed is only available to a limited degree for the Pease International Tradeport. Violations of state erosion and sediment control regulations have been documented; however, the impacts have not been studied.

Littering and illegal dumping are common practices in the Hodgson Brook watershed. Annual cleanups of the banks of North Mill Pond have occurred over the past few years and although there has been a decreased, though substantial removal of trash in the area. Even though the City of Portsmouth and the State both protect against illegal dumping and filling, the amount of trash removed from the area appears to be increasing.

The City of Portsmouth is experiencing an increase in population and growth in businesses, mostly due to the conversion of the former U.S. Air Force Base into the Pease International Tradeport, a center of commercial and industrial businesses. The National Census trends show increased population growth within the watershed boundary. Current public concerns for the increased growth include runoff from sites under construction and post construction runoff, stormwater runoff, road maintenance and an increased amount of impervious surfaces.

Preface

This *Environmental Quality Characterization for Hodgson Brook* presents a comprehensive review of environmental data and information. It is intended to be a scientific guide for the Hodgson Brook Local Advisory Committee. The report describes the geographic area of the watershed, and historic and present trends in environmental quality, development and resource management.

Chapter 1 Introduction

The material presented in Chapter 1 describes the geographic and physical settings of Hodgson Brook. The chapter also provides an overview of the natural resources including wetlands and the animals that inhabit the watershed. The chapter closes with a discussion of the anthropogenic impacts to the watershed.

1.1 Geographic and Physical Setting

The Hodgson Brook watershed is located in the heart of urbanized Portsmouth, New Hampshire (Appendix 1). The watershed covers 2,135 acres, of which, 1,178 acres are in the Pease International Tradeport and the remaining 957 acres are located in the land surrounding the Tradeport in the City of Portsmouth. The watershed supports several different land uses such as an interstate highway (Appendix 2, 3), residential developments (Appendix 3), commercial property (Appendix 3), industry and a variety of undeveloped land uses including wetlands and forests (Appendix 4).

Hodgson Brook is a freshwater stream that originates in the northeast corner of the Pease International Tradeport. The headwaters begin somewhere in the vicinity of the Red Hook Brewery on Corporate Drive but development has obscured the actual beginnings of the Brook.

The natural course of the Hodgson Brook has been altered to meet the development needs of the watershed. The Brook was piped under Corporate Drive and continues to flow underground below the site of the former Pease Air Force Base residences that formerly stood along Corporate Drive. The Brook daylights from the underground pipe at Goosebay Drive. The Brook then meanders through the Tradeport meeting first with Newfields Ditch. This manmade drainage ditch receives surface water runoff from areas east of the aircraft parking apron (MWH Americas, Inc., 2002). The ditch passes through a culvert under Aviation Avenue and then emerges northeast of Portsmouth Avenue where it flows into a wooded area. The ditch joins Hodgson Brook at the intersection of Corporate Drive and Rye Street near the wastewater treatment plant and the recreational baseball fields. The Brook then flows through a wet meadow before meeting with Grafton Ditch (MWH Americas, Inc., 2002).

Grafton Ditch runs parallel to Corporate Drive and flows southeast into Hodgson Brook, near the southeast corner of the air strip apron and Pannaway Manor. Grafton Ditch is divided into Upper and Lower sections. Upper Grafton Ditch is an open surface drainage for approximately 700 feet before it enters a storm drain (MWH Americas, Inc., 2002). Lower Grafton Ditch is the portion of Grafton Ditch that drains into Hodgson Brook, east of Grafton Drive (MWH Americas, Inc., 2002). The ditch was designed to capture surface water runoff from the southeastern section of the base and the former housing areas through storm sewers along Aviation Avenue (MWH Americas, Inc., 2002).

Hodgson Brook flows out of the Tradeport near the Spaulding Turnpike/Rt. 4 and crosses underneath the highway before joining Interstate 95 and the Portsmouth Traffic Circle (US Rt. 1) (Appendix 1). From the Portsmouth Traffic Circle the Brook flows under Coakley Road then flows under the Route 1-Bypass. A branch of the Brook flows parallel to Borthwick Avenue past the Portsmouth Regional Hospital before meeting Hodgson Brook under the Route 1-Bypass. Hodgson Brook then flows parallel to Cottage Street, under the Bartlett Street bridge and it finally joins tidal waters at North Mill Pond.

Land use for the Hodgson Brook watershed shows the watershed is primarily industrial, commercial, or residential (Appendix 3). The Hodgson Brook watershed has about 407 out of 2,135 acres, or 19%, wetlands coverage (Appendix 4).

1.1.1 North Mill Pond

The Advocates for the North Mill Pond (ANMP) (ANMP, 1998), describe the pond's physical environment as a shallow, urban, and tidal surface water. It receives freshwater inflow primarily from Hodgson Brook, which enters the pond from the southwest by passing under the Bartlett Street bridge, and from storm drains and surface runoff along both northwest and southeast shores (ANMP, 1998). The North Mill Pond also receives a sub-tidal flow during flood tides that enter the pond from the northeast under the bridge at Maplewood Avenue. Residential and commercial buildings, roads, a railroad, a cemetery and several parking lots surround a majority of the Pond. The eastern side of the watershed is a combination of residential development and commercial businesses, and has a railroad line running parallel to the shore. The western shore is generally residential but also includes the Route 1-Bypass.

According to the Seacoast Land Trust, the Hodgson Brook watershed does not have any formal conservation easements, but two areas are recognized by the City for protection. The first is located halfway between the Portsmouth Traffic Circle and US Route16/Spaulding Turnpike (Appendix 5). These 12 acres are owned by the State of New Hampshire and are maintained by the New Hampshire Department of Transportation (NHDOT). The area is made up of wetlands, uplands, and ponds. The second area is located in the North Mill Pond watershed and is a 5 acre parcel situated just north of the Maplewood Avenue bridge which crosses North Mill Pond (Appendix 5). The land was part of an estate given to the City of Portsmouth for open space. In the Seacoast, attainment of lands for conservation easements is an ongoing process, with participation by both government (United States Fish and Wildlife Service, New Hampshire Fish and Game Department) and private conservation organizations (Jones, 2000b).

1.1.2 Pease International Tradeport

The Pease International Tradeport occupies the most land (55%) in the watershed. Formerly known as the Pease Air Force Base from the 1950's to 1991, when it was closed, the base was owned and operated by the United States Air Force. The mission of the base was to maintain a combat ready force capable of long-range bombardment operations (US Department of Health and Human Services, 1999). The former Pease Air Force Base is currently under commercial and industrial re-development as the Pease International Tradeport. The Air Force has transferred most of the former base to the Pease Development Authority (PDA) via a 55-year long-term lease in anticipation of eventual deeded transfer (Jerry Dexter, personal communication). Zoning at the Tradeport was adopted by the PDA on December 21, 1991 (http://www.peasedev.org). It provided for four different types of development: a 797-acre airport zone, a 448-acre airport industrial zone, a 333-acre industrial zone, and a 466-acre business/commercial zone (http://www.peasedev.org). The Tradeport now has a fully operational commercial airport and 165 companies renting space from the PDA as of April 2003 (http://www.peasedev.org).

All Tradeport tenants must abide by the PDA rules. “The lessee and any sub lessee or licensee shall comply with the applicable environmental laws and regulations set out in Exhibit G of the lease agreement (Appendix 6), as well as complying with all Federal, state, and local laws, regulations, and standards that are or may become applicable to lessee’s activities on the leased premises” (Pease Development Authority, 1992).

The Pease Development Authority zoning ordinance also set aside 781 acres for natural resource protection and wetlands mitigation (http://www.peasedev.org). In addition, the Great Bay National Wildlife Refuge, which lies outside of the Hodgson Brook watershed, is managed by the U.S. Fish and Wildlife Service and occupies 1,100 acres of the former Pease Air Force Base (Jones, 2000b). The Air Force retained 229 acres of the former base for use by the New Hampshire Air National Guard (http://www.epa.gov).

1.1.3 Highways

The Hodgson Brook watershed has an extensive area covered by highways, roadways and a turnpike (Appendix 2) with 724 acres covered by impervious surface, or 32% of the entire watershed (Fay Rubin, personal communication). DES used an impervious layer in GIS to illustrate the extent to which impervious surfaces cover the Hodgson Brook watershed (Appendix 2). Although this particular coverage (1-meter IKONOS data) is incomplete, it illustrates the extent of impervious cover and the concentration of imperviousness created by the highway and interstate systems. The New Hampshire Department of Transportation (NHDOT) is responsible for the maintenance and repairs of road overlays, or pavement, drainage, roadside vegetation control and any other necessary maintenance on state roads. NHDOT also covers all costs associated with road maintenance repairs.

1.2 Biological Setting

Even though the Hodgson Brook watershed is predominantly covered by residential and commercial development, it supports a diverse community of birds, wildlife, and fish. Of the 2,135 total acres in the watershed, 254 acres are zoned for natural resource protection by the City of Portsmouth (Appendix 3). This means that in these designated areas land uses are limited to natural resource protection as defined by the City of Portsmouth. Permitted uses in designated natural resource protection areas include; temporary activities as authorized by municipal agencies having jurisdiction, tree farms and related forestry activities, wildlife refuge, public parks and playgrounds, and public nature trails. Separate from the 254 acres zoned by the City of Portsmouth, Pease International Tradeport also has designated natural resource protection areas. The natural resource protection zone at Pease covers 781 acres and includes most of the riparian area of Grafton Ditch and a portion of Hodgson Brook as it flows parallel to Corporate Drive in the Tradeport. Besides natural resource conservation areas, the Hodgson Brook watershed also has potential conservation land situated east of Interstate 95 and west of Borthwick Avenue, and NHDOT maintains a conservation easement on a wetland, short scrub forest site near the Spaulding Turnpike/Route 4.

Wetlands comprise 19% of the watershed with 407 acres. There are two potential prime wetlands in the Hodgson Brook watershed according to a wetlands survey recently conducted by the Portsmouth Planning Department (CLD/GES, 2003) (Appendix 7). Prime wetlands are designated according to the function and values assessment criteria provided in State law. In New Hampshire, wetlands are designated "prime" wetlands if they meet all criteria set forth in RSA 482-A: 15 and Chapter Wt 700 of the DES administrative rules. Criteria of prime wetlands include presence of hydric soils, hydrophytic vegetation, wetlands hydrology, at least 50% of the wetland must have Type A Hydric Soils, and the remaining soils must be Type B Hydric Soils (CLD/GES, 2003). The two potentially prime wetland candidates are "014", adjacent to Portsmouth Hospital and I-95, and "015", also near the Portsmouth Hospital and Borthwick Avenue (Appendix 7). Both wetlands are surrounded by development which has the potential to degrade some of wetlands' ecological features (CLD/GES, 2003). Candidate "014" overlays with the City's Natural Resource Protection zone.

1.2.1 Animals

Amongst the buildings and highways, the watershed is home to many animal populations. To date there have not been any comprehensive studies on the animal communities living in the Hodgson Brook watershed. Future studies could provide a better understanding of the animals that inhabit the watershed and which animals are sensitive to environmental changes such as development.

Other studies in southern New Hampshire, in particular *A Technical Characterization of Estuarine and Coastal New Hampshire* (Jones, 2000b), identified southern New Hampshire as an important migratory stopover as well as wintering area for waterfowl. Waterfowl, including black ducks and Canada geese, are present in fall and winter, while cormorants and seagulls are found year-round (Vogel, 1995). Various waterfowl, particularly migrating shorebirds, and aquatic organisms use the mudflat habitat in North Mill Pond (ANMP, 1998). Clams and mussels populations were assessed by the ANMP in 1997 (ANMP, 1998) and their findings suggest there is a small shellfish resource in the pond that may be significant to animals at higher trophic levels. However, these shellfish are contaminated by sewage-borne microorganisms, heavy metals and toxic organic chemicals (Jones and Landry, 2000). Currently the shellfish beds within the pond are closed for harvesting by the DES.

No comprehensive studies are known that specifically identify wildlife in the Pease Tradeport, although Weston (1992) identified some wildlife species such as moose (*Alces alces*) and white tailed deer (*Odocoileus virginiqnus*) inhabiting the area around Grafton Ditch. Other common species sighted include beaver (*Castor canadensis*), mallard (*Anas platyrhynchos*), green backed heron (*Butorides striatus*), and great blue heron (*Ardea herodias*). The Great Bay National Wildlife Refuge, located on the Pease Tradeport, has an inventory of birds observed in the Tradeport area (Appendix 8).

1.3 Human Anthropogenic Setting

This section describes the alterations to the brook based on land use changes in the watershed, historic and present land uses and zoning, and recreational activities both past and present. A close look at the brook reveals that very little of the original watercourse remains. It has been largely altered to accommodate changing human uses and their impacts on the landscape.

1.3.1 Channelization and Piping of Hodgson Brook

Modifications to the natural course of Hodgson Brook were made in order to accommodate the needs of an expanding US Air Force Base, in particular increased stormwater flow generated from runoff. In 1952 the US Army Corps of Engineers began constructing plans to alter the Portsmouth Air Force Base to accommodate the needs of a larger facility. From 1952-1958 the US Army Corps of Engineers expanded the drainage capacity by altering the courses of Hodgson Brook and Grafton Ditch. In 1956, the Hodgson Brook channel was widened to improve flow expected from larger volumes of stormwater runoff generated from the increased amount of impervious surface on the base. The natural meandering characteristic of the brook was replaced with a straighter course from the point of what is today known as the wastewater treatment facility (WWTF) out to North Mill Pond (Appendix 9).

Construction was also performed in Grafton Ditch. A 1952 photo of the Portsmouth Air Force base depicts Grafton Ditch as a stream meandering through a wetland. The Army Corps of Engineers piped the upper portion of Grafton Ditch underground to expand the capacity for stormwater removal. Piping exists between the Air Force hangers, parallel to Aviation Avenue, and reemerges above ground at Grafton Drive (Appendix 10). The underground piping still exists today. The Center for Watershed Protection (CWP) (2003a) found that altering the natural course of a stream will increase the efficiency with which runoff is transported through the stream channel. CWP research suggests that a new stream channel will act as a vector for pollutants found in runoff and the pollutants will be transported downstream. The altered stream, named Grafton Ditch by the Army Corps of Engineers, effectively deals with removing the increased volumes of runoff from the area, but the impacts of the stormwater and any contaminants are seen downstream.

1.3.2 Historic Land Uses in the North Mill Pond Watershed

North Mill Pond, also known as Christian Shore, was first home to a small settlement of six homes, a grist mill, and a shipyard. In the early 1800's this section of the North Mill Pond watershed was bustling with industry, including Raynes Shipyard, tanneries, a railroad and steam powered factories. Since 1850, the Sanborn Fire Insurance Maps have been documenting the different types of industry in Portsmouth, as well as the potential environmental hazards associated with them, such as the location of underground storage tanks. The maps are useful for predicting what types of pollutants may be present based on historic potential sources of pollution in the area. Some industries may have been the first contributors of pollution in the North Mill Pond.

As Portsmouth began to grow, the local citizenry felt that the construction of a bridge over North and South Mill Ponds would ease their travel to Newington and open up more land for houses to be built, thus relieving the congestion in downtown Portsmouth. The growing population and the thirst for industry encouraged development along the banks of North Mill Pond. This development increased the amount of impervious surfaces surrounding the watershed and the potential sources of pollution from runoff and sewage overflows.

On July 7, 1880, a local newspaper read, "The North Mill Pond was drained on Saturday and Sunday nights, the tide gate being lashed open. The rich stores of filth at the bottom, being thus exposed to the hot air, sent fourth loud odors. The white paint on the houses and fences nearest the northeast end of the pond was turned to a dingy brown, the green paint on the window blinds became of a dulled lead color, and a gentleman informs us that the plated work on the harness and carriages in his barn were turned almost jet black" (Pontine Movement Theatre, 2000). There were no conclusions as to how often the tide gates were opened and what created the odors, although the heavy industry along the shores of North Mill Pond may have been of a source. Untreated wastewater expelled from local tanneries, brickyards, and houses surrounding the pond were also potential sources. Loading of organic wastes undoubtedly caused intense oxygen demand, creating completely anaerobic conditions in the pond with accompanying buildup of reduced sulfur compounds and hydrogen sulfide.

After 1860, Portsmouth and Newington continued to grow and develop. The US Naval Shipyard brought many people to the area and thus began the commercial growth of the greater watershed. The history and development of North Mill Pond has been documented in the local newspapers, however, there is little documentation on the development of the Hodgson Brook watershed until the Air Force Base was built in the 1950's.

1.3.3 Present Land Use and Zoning

Today, the Hodgson Brook watershed, including the Pease International Tradeport, is zoned for commercial, industrial, and residential development as well as natural resource protection (Appendix 3). The watershed is found within two municipalities, mostly in Portsmouth and a small area in Newington.

Most of the commerce and industry within the watershed boundary is situated inside the Pease International Tradeport. The largest portion of the Tradeport and the watershed is zoned as Airport Business Commercial (Appendix 3). This includes companies such as Air Traffic Limited, High Tech Aircraft Corp, Port City Aircraft Repair, S& J Aviation LLC, Pan Am Services, and Pan American Airways Corp. The tenants of the Tradeport are managed by the PDA and follow a lease agreement that includes compliance with environmental regulations (Appendix 6). As of April 2003, there were 165 tenants residing in the Pease International Tradeport. Aside from the airport businesses, many tenants are computer software and computer manufacturing companies. Outside the Tradeport several businesses are located along the Rt. 16 Spaulding Turnpike, Rt. 1 Bypass, Borthwick Avenue and Islington Street including Home Depot, Hampton Inn, Meadow Brook Inn, Port City Inn, Pontiac Oldsmobile, U-Haul, Frank Jones Conference Center, Liberty Mutual Insurance and the Portsmouth Regional Hospital, to name a few.

According to the Portsmouth Planning Department, the second largest area within the watershed is zoned as Natural Resource Protection with a total of 254 acres (Appendix 3). The third largest zoning area is residential with a total of 230 acres (Appendix 3). These three areas comprise the majority of the land use within the watershed. Information about the changes in industry and growth of the watershed can be found in Section 3.1.

Currently all designated wetlands within Portsmouth are protected by a 100 foot buffer, except in Pease International Tradeport where wetlands are not required to have a buffer zone (Miller, personal communication). Riparian buffers can provide several functions, including bank stabilization; shade, shelter and food for aquatic organisms; wildlife habitat; a filter for sediments, nutrients, pesticides, and toxic organics in stormwater runoff. The PDA recommends a 25-foot buffer zone in the Tradeport, but since there is no mention of buffers in the PDA Land Use Controls, no enforcement can be made. In Portsmouth, prime wetlands, approved first by the City Council then by DES, are carefully reviewed before any project in the area can begin. All projects that are in or adjacent to the prime wetland are considered to be “major” projects and require an inspection by the DES and a public hearing. The State regulates all activities of prime wetlands. Within the next year, it is expected that the Portsmouth City Council will review all potentially prime wetlands characterized in the City-wide Wetlands Inventory (Britz, personal communication).

Both 100 ft and 250 ft buffers were drawn around Hodgson Brook to create a buffer map (Appendix 11). The maps depict the extent of the buffer regions in relation to roadways. Land use in these buffer areas would potentially have the greatest contaminant impact to the brook since they are the first defense the river has against pollution. Buffer areas can theoretically protect surface waters but are less able to do this when they become developed.

1.3.4 Recreational Resource

While not much information is available about the past recreational uses of Hodgson Brook, accounts of a variety of recreational uses are available for North Mill Pond through the efforts of a local theatre, the Pontine Movement Theatre. Pontine researched development of the community around the North Mill Pond during the mid 1800s. Numerous newspaper articles from that era discussed the use of North Mill Pond for ice skating. For example, an article dated February 20, 1856 states, “The season has now arrived when old and young enjoy themselves in the pleasant exercise of skating. For several evenings, both the North and South ponds have been visited by hundreds of both sexes when there is good skating. Now a question that I wish to ask is: Is there no way in which people could be made to stop cutting eel holes and endangering the lives of so many?" Sometimes the ponds were flooded in order to generate fresh ice for public skating. Besides skating, the pond was used in the winter for horse and sleigh races. An article in the *Daily Morning Chronicle* on February 5, 1857 discussed this spectator sport on North Mill Pond (Pontine Movement Theatre, 2000).

Today activities like kayaking and fishing are popular on the pond. Anecdotal accounts have been noted of people fishing off the Maplewood Street Bridge for striped bass. In addition, the ANMP conducted their first annual fall paddle on North Mill Pond in 2002.

The DES has closed off all shellfish harvesting in the pond since there are no data showing that a growing area has acceptable sanitary quality to allow for harvesting, thus it is classified as "Prohibited/Unclassified" (Chris Nash, personal communication). DES follows guidelines by the National Shellfish Sanitation Program for classifying shellfish growing waters to ensure the protection of public health (Nash, 2001).

The ANMP conducted shellfish resource surveys in the North Mill Pond using the New Hampshire Estuaries Program (NHEP) Shoreline Evaluation during 1997. The survey provided a qualitative description of mussel and oyster abundance and clam hole densities in the area (ANMP, 1998). The study revealed shellfish resources appear to be more abundant in the less impacted areas along the southeastern and northwestern sides of the Pond.

Recreation in other areas of the Hodgson Brook watershed include fields in the Pease Tradeport, bird watching, and biking along the Seacoast bike path which crosses through the Pease Tradeport, connecting Portsmouth with Newington and points north.

Chapter 2 Environmental Quality: Historical Trends and Present Status

The information presented in Chapter 2 describes historical trends and the present status of microbial, chemical and other contaminants in water and sediments, their sources and potential public health impacts.

2.1 State Standards and Regulations

2.1.1 Bacteria, Toxic Chemicals, and Alteration of Terrain Regulations

In 1972 Congress adopted the Clean Water Act (CWA), which established a framework for achieving the national objective to restore and maintain the chemical, physical, and biological integrity of the nation's waters (http://www.epa.gov). By adopting the CWA, Congress declared that water quality provides for the protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water. Under the CWA, each state is responsible for creating its own water quality standards to be used as benchmarks against which monitoring data are compared to assess the health and intended use of a particular body of water. Section 305 (b) of the CWA requires states to assess the health of their waters and the extent to which water quality standards are being met.

In the State of New Hampshire, surface water is classified into three different categories, depending on the waterway type and intended use. These categories allow the DES to classify water as swimmable, fishable, and safe for shellfish harvesting.

New Hampshire uses the bacterial indicators fecal coliforms, enterococci and *Escherichia coli (E. coli)* to assess the sanitary quality of water. Presently, fecal coliforms are used for shellfish growing waters, enterococci for recreational uses of marine and estuarine waters, and *E. coli* is used to assess freshwater recreational uses as recommended by the EPA (DES, 2000). A summary of these standards can be found in the Table 1.

Table 1 New Hampshire Standards for the Sanitary Quality of Water

NH Bacterial Indicator Standards for Surface Water Classification

Surface water	Classification	Indicator	Geometric mean concentration (counts per 100ml)	Maximum limit concentration (counts per 100ml)
Freshwater recreational	Class B	*Escherichia coli*	<126	<406
Tidal recreational		Enterococci	<47	<104
Shellfish growing	Approved	Fecal coliforms	<14	>43
	Restricted	Fecal coliforms	14-88	>260
	Prohibited	Fecal coliforms	>88	-

Both Hodgson Brook and North Mill Pond are classified by the State as Class B waters. Class B is the second highest water quality classification level in the state, and is considered acceptable for fishing, swimming and other recreational purposes.

Compliance with the CWA restricts levels of toxic chemicals in streams in order to protect aquatic life and human health. At the present time, chemical analyses are the primary means of determining compliance of State's surface waters with the CWA and State standards (DES, 2000). Furthermore, any point source and most stormwater discharges in the state are required to obtain a federal NPDES permit and a state discharge permit to regulate the level of toxic chemicals, pathogens, nutrients, suspended solids, and biological oxygen demand (BOD) discharged into the waterway (DES, 2000). In 1990, the state adopted regulations which require all waters to be free from toxic pollutants or chemicals constituents in concentrations or combinations that:

a. Injure or are inimical to plants, animals, humans, or aquatic life; and
b. Persist in the environment or accumulate in aquatic organisms to levels that result in harmful concentrations in edible portions of fish, shellfish, other aquatic life, or wildlife which may consume aquatic life (DES, 2000).

The State uses RSA 485 to protect waterways from the impacts of development or alterations in the landscape. The provisions of RSA 485-A: 17 protect surface water quality from degradation resulting from any activity that significantly alters the terrain or occurs in or on the border of the surface waters of the State. All waterways and wetlands within the state are protected from illegal dumping and filling. Under RSA 482-A:3 Excavating and Dredging Permit, “no person shall excavate, remove, fill, dredge or construct any structures in or on any bank, flat, marsh, or swamp in and adjacent to any waters of the state without a permit from DES” (http://www.gencourt.state.nh.us/rsa/html/L/482-A-3.htm).

2.2 Fecal Borne Microbial Pollutants

One of the most common issues facing environmental managers concerned with surface water quality is fecal-borne microbial pollution and the threat of diseases to humans who come in contact with water or shellfish from contaminated areas. For purposes of monitoring the sanitary quality of surface waters, fecal coliforms, enterococci and *E. coli* have served well as indicators of water quality for classifying waters to protect public health. Efforts to reduce contamination involve making an assessment of what potential sources may be significant, conducting intensive sampling, eliminating identified sources and then re-sampling surface waters to see if improvements in water quality have occurred. Much progress in improving water quality in the Seacoast has been made using this traditional approach. However, as many of the obvious sources of pollution, such as untreated sewage from inadequate wastewater treatment facilities, have been eliminated or reduced in significance, residual contamination that limits uses of surface waters is often of unknown origin. With increasing development pressure in the Seacoast region, new sources of fecal pollution are also a problem for the State's estuarine waters. A new technique for tracking sources of fecal-borne microorganisms, *E.*

coli ribotyping, is now being used in NH that allows identification of the actual source species responsible for pollution (Jones, 2003; Jones, 2002; Jones and Landry, 2003).

2.2.1 Status and Trends

According to a recent report, no documented incidents or reports of waterborne illnesses have occurred in New Hampshire since the last report published in 1998 (DES, 2000). In North Mill Pond, the state enterococci standard for tidal recreational waters was exceeded based on 2000 data (DES, 2000). This suggests that humans should avoid exposure to pond water to prevent waterborne illness.

Some shellfish beds in the state's estuaries are closed due to either bacterial indicator measurements exceeding the allowable standards established by the US Food and Drug Administration, or because data are lacking that would allow the beds to be opened in accordance with federal shellfishing guidelines (DES, 2000). Although a sanitary survey of North Mill Pond has not been conducted for the purposes of shellfish harvesting classification, data collected through other studies show microbial pollution flowing into the Pond from storm drains and Hodgson Brook, resulting in bacterial levels in excess of state standards. Shellfish harvesting is not allowed within the 7.27 square mile Piscataqua River watershed, including North Mill Pond (DES, 2000).

The Great Bay Coast Watch (GBCW) has established two surface water sampling sites on North Mill Pond at Maplewood Avenue (GB 18) and Bartlett Street (GB 19). Monthly sampling for fecal coliform has been conducted from April- December each year at low and high tides, since 1997 (Reid et al., 2000). The high tide annual geometric mean fecal coliform concentration at Bartlett Street (GB 19) for 1997-2002 ranged from 49 to 541cfu/100mL (Tables 2, 3) (Reid et al., 1998, 2000, 2001, 2002, 2003). For 1997 to 2002, low tide fecal coliform concentrations ranged from 67 to 597cfu/100mL (Reid et al., 1998, 2000, 2001, 2002, 2003).

The high tide annual geometric mean fecal coliform concentrations at Maplewood Avenue (GB 18) for 1999-2002 have ranged from 2 to 70cfu/100mL (Tables 2, 3) (Reid et al., 1998, 2000, 2001, 2002, 2003). For 1999-2002 the low tide concentrations ranged from 13 to 460 cfu/100mL (Reid et al., 1998, 2000, 2001, 2002, 2003). Thus, the annual geometric mean fecal coliform concentrations have exceeded the standard of 14/100/ml most years at both sites. However, although GB 19 had the highest annual geometric mean fecal coliform concentration in the entire GBCW network in 1997, 1999, 2000, and 2001, the geometric mean fecal concentrations at GB 19 have been decreasing each year.

Only a few studies of microbial and other types of pollution have been conducted in the Hodgson Brook/North Mill Pond watershed. The Advocates for the North Mill Pond measured total coliform and *E. coli* concentrations in water samples collected from sites in Hodgson Brook, North Mill Pond and from storm drains that discharged to North Mill Pond during 1997 (ANMP, 1998). Most of the sampling for microbial pollutants was conducted during a storm event, and the data are summarized in a following section (2.2.2.1 Storm Related Runoff).

Jones (2000a) collected samples from August 1999 through June 2000 in Hodgson Brook, North Mill Pond and various storm drains during dry and wet weather. Two of the sampling sites used in study, GBW 18 and GBW 19, are the same as sites GB 18 and GB 19 used in the GBCW program. The geometric average *E. coli* concentration in

Hodgson Brook water samples, collected slightly upstream of Alltex Cleaners, was 90 ± 4.3 cfu/100mL, the geometric mean fecal coliforms during dry and wet weather was 91 ± 4.5 cfu/100mL, and the average enterococci concentrations was 96 ± 3.9 cfu/100mL. At GBW 19, the GBCW Bartlett Street site, the geometric average *E. coli* concentration was 1050 ± 4.1 cfu/100mL, the geometric mean fecal coliforms during dry and wet weather was 1430 ± 4.1 cfu/100mL, and the enterococci concentration was 612 ± 5.2 cfu/100mL. At GBW 18, the GBCW site at Maplewood Avenue, the geometric average *E. coli* concentration was 41 ± 5.8 cfu/100mL, the geometric mean fecal coliforms during dry and wet weather was 23 ± 3.3 cfu/100mL, and the enterococci concentration was 28 ± 7.0 cfu/100mL. The decrease in *E. coli* and enterococci between the Bartlett Street and Maplewood Avenue sampling sites suggest that bacteria are being flushed between the two sites.

2.2.2 Sources of Fecal Borne Microbial Contaminants

Potential sources of fecal borne bacteria in the New Hampshire coastal region include, but may not be limited to, urban stormwater runoff, illicit and cross connections in storm drains, agricultural runoff, illegal discharges from boats, pets, birds and wild animals, resuspension of contaminated sediments and overloading of wastewater treatment facilities (Jones, 2000b). Stormwater runoff has been documented as one of the most significant sources of bacteria to coastal waters in New Hampshire (Jones and Langan, 1996a). Potential sources in the Hodgson Brook watershed include stormwater runoff from impervious surfaces, dry weather discharges from storm drains, aging wastewater treatment infrastructures, accidental discharges from the wastewater treatment plant, pets, birds and wild animals. Information about microbial contamination in the Hodgson Brook watershed is only available for the mouth of Hodgson Brook and North Mill Pond. Microbial indicator data are needed for the upper portion of the watershed, including the headwaters, to ascertain pollution levels and the sources of any significant pollution.

Recent technological developments at UNH allow for tracking of fecal pollution types using *E. coli* ribotyping. Ribotyping is a genotypic-based technique that uses the bacterial DNA in water samples to match bacterial DNA data from known bacteria sources such as humans, dogs, otters and raccoons. When used along with traditional measurements of bacterial concentrations, it becomes a useful strategy that goes beyond identifying problem areas or potentially significant sources. Ribotyping has the capability to identify actual source species that are present and their level of significance, allowing for better focusing of expenditures of valuable and limited resources for pollution source elimination.

Table 2 Fecal Coliform Geometric Mean Concentrations (cfu/100ml) in North Mill Pond Collected by Great Bay Coast Watch 4/97-6/00

	North Mill Pond			
	GB 18		GB 19	
	Maplewood	Avenue	Bartlett	Avenue
DATE	Low tide	High tide	Low tide	High tide
4/23//97	180	10	22	10
5/6/97	40	10	50	10
5/22/97	*	*	*	*
6/5/97	0	0	170	100
6/23/97	150	10	450	370
7/7/97	0	*	760	210
7/21/97	70	0	510	280
8/4/97	140	*	1100	*
8/19/97	110	0	TNTC	200
9/3/97	30	0	510	30
9/18/97	*	*	*	*
10/2/97	30	0	220	0
10/17/97	40	0	1030	20
11/9/97	*	*	*	*
5/12/98	460	70	440	300
6/10/98	10	20	300	140
7/9/98	60	20	100	30
8/10/98	50	0	50	10
9/9/98	60	0	230	240
10/7/98	10	0	0	0
11/5/98	10	0	0	100
4/29/99	0	10	100	300
5/17/99	10	0	0	300
6/15/99	10	0	1380	200
7/13/99	100	20	6600	200
8/12/99	320	0	3800	480
9/13/99	0	0	80	200
10/12/99	0	0	4	3
11/9/99	200	10	860	6600
4/19/00	50	10	2150	855
5/18/00	20	0	1800	1500
6/19/00	370	30	3200	1000
Geo. Mean	27	3	230	98
7/99 to 6/00	34	4	735	385

*Sample not collected.

Detection limit = 1/100ml for 100ml sample filtration

Source: Jones, S.H. 2000a. *Strategy for identifying priority to urban contamination sources to coastal waters*. Final Report to the New Hampshire Coastal Program Office of State Planning. Concord, NH. Data based on Reid et al., 1998-2001.

Table 3 Great Bay Coast Watch Water Quality Parameters at Maplewood Avenue and Bartlett Street 1998

Date	WTempL oC	WTemp H oC	DO-L ppm	DO-H ppm	Sal-L ppt	Sal-H ppt	Sat-L %	Sat~H %	pH-L	pH-H	Fecal L CFU/100	Fecal H CFU/100	LP L cm	LP H cm	Depth. cm	Depth cm	ATemp L oC	ATemp H oC
Site 18: Maplewood Avenue																		
22-Apr	8	9.5	9.9	10.4	13.9	17.1	91.24	101.23	7.4	7.8	180	10	90	*	90	*	9	15
5-May	8	8.5	9	8.9	22.7	23.5	87.71	88.19	7.6	7.8	40	10	15	205	15	280	8	9
21-May	8	11	8.7	9.6	24.7	24.5	85.91	101.29	7.6	7.8	*	*	22	167.5	22	265	9	17
4-Jun	12	14	8	9.5	27.15	28.2	87.74	109.4	7.3	7.9	60	0	28	250	28	280	10	18
6-Jul	16	17	8.7	7.7	30.3	29.9	105.73	95.2	7.8	7.6	*	*	33	250	33	250	29	26
20-Jul	17	17	6.8	8.2	29	28.35	83.59	100.39	7.7	7.8	70	0	20	215	20	215	18	17
22-Aug	18	17	8.2	8.9	28.9	29.2	102.71	109.54	7.8	7.8	150	10	20	192.5	20	250	22	28
3-Aug	18	17.5	6.6	8.4	28.6	30.6	82.51	105.32	7.8	8.1	TNTC	*	20	245	20	245	18	25
18-Aug	16.5	16	6.3	8.2	30.3	30.45	77.32	99.75	7.8	7.9	110	0	30	270	30	270	16	22
2-Sep	18.5	19	6.1	7.9	30.15	31.2	77.74	102.32	7.7	7.8	30	0	30	245	30	245	17.5	19
17-Sep	17	18	6.2	7.6	30.4	30.2	76.89	95.97	7.8	8.1	*	*	30	270	30	270	17.5	29
1-Oct	9	12.5	7.4	8.5	29.9	30	77.4	95.98	7.8	7.9	30	0	30	225	30	225	9	18
16-Oct	10.5	13	7.5	8.9	29.35	31.5	80.79	102.58	7.6	8	40	0	30	275	30	275	5	17
8-Nov	10	11	7.6	8.7	22.3	27.1	77.32	93.35	7.5	7.7	*	*	25	215	25	235	8	14.5
Site 19: Bartlett Street																		
Date	WTempL oC	Wtemp H oC	DO-L ppm	DO-H ppm	Sal-L ppt	Sal-H ppt	Sat-L %	Sat-H %	pH-L	pH-H	Fecal L CFU/100	Fecal H CFU/100	LP L cm	LP H cm	Depth. cm	Depth cm	ATemp L 0c	ATemp H 0c
22-Apr	8	11	10.4	10.6	1.1	12.7	88.82	103.94	7.4	7.5	22	10	22	83	22	83	12	14
5-May	9	10	9.5	11.2	2	2.6	83.54	101.15	7.5	7.6	50	10	17	88	17	88	10	11
21-May	11	14	9.4	11.8	1.9	7.9	86.58	120.2	7.2	7.6	*	*	25	60	25	60	12	18
4-Jun	13	15	7.9	9	0.3	1.5	75.45	90.4	7.8	6.9	170	100	20	75	20	75	11	17
22-Jun	20.5	23	7.7	7.3	1.1	2.2	86.38	86.43	8	7.9	450	370	12.5	78	12.5	78	26.5	27.5
6-Jul	18	24	8.8	10.8	2.1	13.5	94.41	138.32	7.8	8.2	760	210	10	55	10	55	23	29
20-Jul	18	19	8	9.1	9.6	25.6	89.42	113.85	7.7	8.1	510	280	10	75	10	75	19	20
3-Aug	19	21	8.4	8.9	1.8	2	91.82	101.31	7.8	7.8	TNTC	*	10	65	10	65	19	21
18-Aug	16	21	8.6	9.8	1.5	17.95	88.23	121.73	7.1	7.6	TNTC	200	5	72.5	5	95	15	26
2-Sep	19	19	8.9	9.1	1.35	13	97.05	105.76	8.1	7.6	510	30	10	65	10	65	21	21
17-Sep	16	19	8.8	8.9	2.2	7.6	90.63	100.37	7.6	7.8	*	*	10	110	10	110	18	28
1-Oct	9	12	10.6	10.7	1.6	22	93	113.55	7.5	7.8	220	0	5	60	5	60	4	16
16-Oct	10	12	9.9	9.1	1.8	28.1	89.04	100.43	INV	7.8	1030	20	10	125	15	125	5	16.5
2-Nov	11	11.5	8.3	8.5	1.15	1.48	76.12	78.99	7.1	7.1	*	*	25	90	25	90	8	14.5

DO = Dissolved Oxygen; Sal = Salinity; Sat = Saturation; LP = Light Penetration; WTemp = Water temperature; ATemp = Air Temperature; TNTC = Too numerous to count; INV = Invalid

Source: Konisky, R et al. 2000. *Great Bay Coast Watch 1990-1999 A Ten Year Report on the Volunteer Water Quality Monitoring of the Great Bay Estuarine System*. University of New Hampshire Cooperative Extension/Sea Grant Durham, New Hampshire.

2.2.2.1 Storm Related Runoff

In coastal New Hampshire and some other areas of the US, the major recognized source of microbial contamination to surface waters is stormwater runoff (Jones, 1999). Stormwater runoff is especially significant in urbanized areas where rain falls onto impervious surfaces, including pavement, roofs, sidewalks, patios, bedrock outcrop, compacted soils and grassy surfaces (Arnold and Gibbons, 1996), is unable to infiltrate into surface soils, and runs off into stormwater control systems, eventually flowing into surface waters. Fecal material and other wastes that are present on impervious surfaces are washed off and carried along with the rainfall or snowmelt runoff into surface waters. Pollutant loads from stormwater runoff increase as both the amount of impervious surface and the length of the antecedent dry weather period increases. Thus, the frequency of rainfall influences the accumulation of pollutants on impervious surfaces that can be washed into surface waters.

Recent studies have focused on the impacts of stormwater runoff on downstream surface waters and the presence of fecal bacteria in stormwater. According to Jones and

Langan (1996b), runoff from impervious surfaces in urban areas contains measurable amounts of hazardous contaminants, including microbial pathogens/indicators. Stormwater related pollutant loading is a major concern in the Seacoast region where bacterial pollution presently limits uses like shellfish harvesting and recreation.

Only a few studies on microbial pollution associated with storm water runoff have been conducted in the Hodgson Brook/North Mill Pond watershed. The Advocates for the North Mill Pond (ANMP, 1998) measured *E. coli* concentrations in water samples collected from sites in Hodgson Brook, North Mill Pond and from storm drains that discharged to North Mill Pond during major rainfall/runoff event in 1997. On November 1-2, 1997, water samples were collected near the mouth of Hodgson Brook slightly upstream of Colonial Cleaners. The storm event produced a significant increase in flow at the Hodgson Brook site (12 L/s base flow to 1670 L/s peak flow) during the study period. *E. coli* levels increased from 110 cfu/100 mL during first flush (106 L/s) to 510 cfu/100mL after peak flow (760 L/s). Thus, the instantaneous loading of *E. coli* increased from 1.17×10^5 cfu/s to 4.26×10^7 cfu/s, an increase of >36 times.

Other evidence exists that storm-related bacterial pollution is a significant concern to Hodgson Brook, at least near its mouth (Jones, 2000a). Samples were collected from August 1999 through June 2000 in Hodgson Brook, North Mill Pond and various storm drains during dry and wet weather. The geometric average *E. coli* concentration in Hodgson Brook upstream of Alltex Cleaners (same site as for ANMP, 1998) was 83 ± 4.7 cfu/100mL during dry weather and 110 ± 3.9 cfu/100mL during wet weather. Enterococci showed a more pronounced weather related difference, with 67 ± 3.9 cfu/100mL during dry and 224 ± 2.9 cfu/100mL during wet weather.

Bacterial concentrations were much higher at the downstream site at the mouth of Hodgson Brook (GBW 19). Enterococci again showed a pronounced weather-related difference, with 494 ± 5.3 cfu/100mL during dry and 1160 ± 4.7 cfu/100mL during wet weather. Average instantaneous flow rates showed wet weather flow to be significantly greater than dry weather flow at both sites, suggesting that loading of bacterial contaminants during wet weather can contribute significant levels of bacterial pollution. The highest loading estimates for a single event at GBW 19 were 7.2×10^7 cfu/s and 7.8×10^8 cfu/s for *E. coli* and enterococci, respectively. These results also suggest that, because pollution levels are much greater at the downstream site, GBW 19, than at the upstream site above Colonial Cleaners, pollution may be entering the brook from a culvert between the two sites. The bacterial contaminant loading values at site GBW 19 were the highest of three study sites for which loading estimation was possible. As a result, GBW 19 is considered a high priority site for follow-up studies.

The transport and fate of indicator and pathogenic microorganisms in stormwater runoff can be affected by a variety of physical, chemical and biological factors. The main factors that affect the transport and fate of the microorganisms of concern in the effluent are their relationship to suspended particles, their detention time within the stormwater systems and the presence of water in the systems between runoff events (Jones, 1999). Microorganisms in stormwater runoff in New Hampshire coastal communities have been found to adhere to sediment particles depending on the organism's size and species, and accumulate in bottom sediments. If a particular microorganism adheres to a particle, it can remain in the environment and potentially cause pollution of surface waters since sediments can be resuspended.

Ten stormwater control sites were monitored in the Great Bay watershed, including a Hodgson Brook watershed site at Costco, today known as Home Depot. Jones and Langan (1996b) determined that the runoff from the Home Depot building roof and the back shipping areas was actually cleaner than the water discharging from the device constructed to treat the parking lot runoff. The study showed that stormwater runoff, even after it passed through a treatment system, could be a source of pollution.

The ANMP conducted a study of the environmental quality of North Mill Pond, which confirmed the occurrence of significant storm related fecal pollution (ANMP, 1998). With 32% of the Hodgson Brook watershed covered by impervious surfaces, it is crucial to identify and eliminate sources of microbial pollution to protect water quality.

2.2.2.2 Storm Drains

Although many studies have attributed elevated levels of bacteria pollution in surface waters to runoff, most studies do not distinguish actual storm runoff from other discharges within storm drain systems. Storm drainage infrastructure is designed to serve as a conduit for stormwater runoff, from roadways and other surfaces, to flow into waterbodies. Numerous studies suggest that storm water drainage and control systems may enhance survival and potentially support regrowth of bacterial contaminants (Jones and Langan, 1996a; Jones, 1998). Jones and Langan (1996a) reported increasing concentrations of fecal coliforms and *E. coli* in storm water control systems that contained standing water during dry weather, and attributed this to either unidentified continuous sources or to regrowth. In a later study (Jones, 1999), results showed that wet ponds were consistently effective at removing bacteria from runoff water and that bacteria may regrow in other types of control systems that are moist and nutrient rich during dry weather periods. This is one reason why sampling during dry weather conditions is important for determining the levels of contamination under different conditions.

Although storm drains carry stormwater runoff during rain events and snow melts, dry weather discharges have also been documented in Seacoast communities. O'Shea and Field (1992) emphasized the importance of dry weather flow as an indicator of cross connections associated with sewer systems. Cross connections can be significant sources of bacteria in storm water drainage systems and possible sources of human-borne pollution. Dry weather discharges have been investigated in many of the NH coastal communities and documented sources of illicit discharges included sanitary wastewater and grey water (Landry, 1999). Illicit discharges make it difficult to distinguish between stormwater runoff and other discharge as sources of microbial contamination during storm events because residual contamination from dry weather ands chronic discharges may comprise the stormwater mix. Because the discharges from storm drains are comprised of more than just runoff, the sources of the microbial contaminants cannot be distinguished by simply measuring concentrations. More in-depth study using ribotyping have been used to distinguish various sources in storm drains (Jones and Landry, 2003).

Sampling discharges from storm drains during both dry and wet weather helps to distinguish differences in water quality during low and high flows. There have been numerous studies conducted in coastal New Hampshire on microbial contamination associated with storm drains. Although the studies were not located in the Hodgson

Brook watershed, the results provide insight into the significance of this source in the Seacoast. Studies in Dover, Exeter and other areas have documented contamination from residential and commercial areas and in stormwater discharge pipes (Jones and Gaudette 2001, Jones 2000a, Jones, Gaudette and Mosher, 1999; Jones 1999, Jones and Langan 1996b). Jones and Gaudette (2001) examined bacterial and trace metal contaminants from urban storm water drainage systems in Exeter and Dover. Water samples were collected from storm drains and the receiving waters during wet and dry weather conditions and analyzed for fecal indicator bacteria and trace metals. These results confirm previous studies that have shown storm drains to be significant sources of bacteria and trace metals, especially during high flows and wet weather (Jones, 2000a; Jones, 1999). Suspected sources include cross-connected sanitary sewage pipes and unknown sources of non-enteric pathogens.

Landry (1997) found illicit sanitary wastewater connections and leaky sewer mains in some stormwater drainage pipes, while sources for remaining drains were probably cross-connected sanitary sewage lines, and non-human sources of bacteria throughout the seacoast area. These findings are not isolated instances. There have been illicit connections found in the City of Portsmouth by DES, the ANMP and the Portsmouth Department of Public Works.

The DES has conducted extensive investigations of certain municipal storm drainage systems throughout Portsmouth. DES also identified stormdrain outfall locations around the North Mill Pond and up Hodgson Brook to the Rt. 1-Bypass using a global position system (GPS) (Appendix 13). DES has found persistent dry weather discharges along the Dennett Street drainage area, which flows directly into North Mill Pond. The City of Portsmouth investigations of this system revealed that sewer systems are exfiltrating into the storm drainage system. In response, the City has proposed a project to eliminate exfiltration from the sewer and inflow from storm drains, through the separation of storm and sewer structures and addition of new sewer pipes (Rice, 2002). As of May 2003, the City of Portsmouth has mapped the locations of several storm drainage systems in the Hodgson Brook watershed (Appendix 14). The City will complete the mapping project by December 2003.

Stormwater is regulated by the US Environmental Protection Agency under the Clean Water Act. The *Phase I Stormwater Regulations* regulate activities of all industrial facilities and municipalities with populations greater than 100,000 that may discharge into storm systems and developers that disturb greater than 5 acres of soil (http://www.des.state.nh.us/stormwater). Beginning in March 2003, urbanized areas with populations between 50,000 and 100,000, and developers disturbing between 1-5 acres were subject to new requirements known as *Phase II Stormwater Regulations* (http://www.des.state.nh.us/stormwater). Portsmouth has a population less than 50,000 but is in an urbanized area of that size required in *Phase II Stormwater Regulations* (http://www.des.state.nh.us/stormwater/docs/phase2/fact2-2.pdf and http://www.des.state.nh.us/StormWater/nhurb2000.pdf). The EPA regulates *Phase II* for New Hampshire, under the National Pollutant Discharge Elimination System (NPDES) permits program.

The City was responsible for submitting a Notice of Intent (NOI) to the EPA by March 10, 2003. Since the City has a separate municipal storm sewer system (MS4) and it meets the population level, they were required to submit an NOI (http://www.des.state.nh.us/stormwater). The NOI provided a timetable for mapping the storm drain system, plans for detecting and fixing illicit discharges, cleaning the storm drain system, and educating the public about stormwater pollution.

The stormdrain mapping project which is underway will aid with implementation and compliance of DES surface water quality regulations and *Phase II Stormwater Regulations*. City of Portsmouth officials hope this project will help to develop a complete inventory of culverts, wetlands, pipes and all waterways. The information gained will then be put into GIS format to be used in management of the storm sewer system. It is hoped that this project will bring a better understanding of water sources and flows that enter the Hodgson Brook watershed.

2.2.2.3 Wastewater Treatment Infrastructure

Wastewater treatment facilities are, ideally, capable of reducing microbial contaminant concentrations to meet required criteria in wastewater 100% of the time. However, this does not occur in practice. Changes in waste stream characteristics that modify treatment efficiency, equipment problems, operational changes, human error and natural events/disasters/events beyond control all influence the effectiveness of WWTFs (Jones, 2000b). In many urban areas, the sewage system infrastructure and stormwater drainage systems occupy the same space and can intermix to varying extents (Jones, 1999). Some coastal WWTFs and sewer systems have limited capacities for handling stormwater during major storm events.

Stormwater can overburden facilities and require bypassing of pump stations during storm events (Jones, 2000a). Under these conditions, inadequately treated wastewater is discharged to surface waters and significant loading of bacteria can occur.

The Pease International Tradeport WWTF is located in the Hodgson Brook watershed on Rye Street and is owned and maintained by the City of Portsmouth. The facility completes monthly water quality reports and is responsible for reporting any raw or partially treated discharges or overflows to the DES Shellfish Program. Overflows and discharges which exceed the WWTF capacity could flow into Hodgson Brook and impact the water quality. The most recent reportable discharge incident occurred on October 23, 2002. A camper with a pickup truck was looking for a place to dump their holding tank waste. A city employee pointed in the direction of where they thought the discharge was and informed the pickup owner that they needed to talk with the WWTF operators before dumping (Rice, 2002). The WWTF operator was informed by the other employee instead and went out to find the owner of the pickup had already dumped 15 gallons of wastewater into the catch basin. The catch basin was vacuumed out and a bacterial sample was taken at the culvert discharge. To prevent this mistake from happening in the future the City painted “No Dumping” signs at each catch basin.

Another recent WWTF discharge incident occurred on June 20, 2002, when up to 200,000 gallons of sewage had leaked from the primary clarifiers into a drainage swale which leads into Hodgson Brook (Nash, 2002). After an investigation it was determined the Primary Logic Controller (PLC) failure and lack of programming providing the alarm for the PLC were the cause. Water samples were taken for fecal coliform counts and results concluded no further action was necessary. Thus, discharges associated with the

Pease WWTF occur occasionally and may contribute microbial contamination to the Hodgson Brook watershed on an infrequent basis.

2.2.2.4 Pet Waste

Pets can be a source of fecal contamination to water via runoff and thus pose a threat to public health. The City of Portsmouth regulates how pet waste is handled. The Portsmouth, NH Article IV, Section 9.401 Removal of Excrement reads, “It shall be unlawful for the owner or person in control of any dog to allow that dog to appear in any public place or upon the property of any other person unless said owner or person in control has in his or her possession a mechanical or other device for the removal of excrement; nor shall said owner or person in control fail to expeditiously remove any such excrement deposited by said dog in any such place. This ordinance shall not apply to a blind person while walking his or her guide dog” (Adopted 10-6-86). According to animal control officer Austin Wallace this is the only ordinance for the City of Portsmouth that pertains to the removal of dog excrement (per communication).

No direct evidence of pet waste loading in runoff is available, and microbial source tracking studies have not been conducted in Hodgson Brook to determine the significance of pets as fecal pollution sources.

2.2.2.5 Birds and Wild Animals

Fecal waste from birds and wild animals may also contribute to the degradation of surface water quality (Jones, 1999). Although their feces do not contain human enteric viruses, bird and wildlife feces may contain a variety of bacteria pathogenic to humans. There have been no studies on the existence or significance of birds and wild animals as sources of fecal pollution in the Hodgson Brook watershed.

Recent studies using ribotyping of *E. coli* to track sources of fecal pollution have been conducted in coastal New Hampshire. Although the studies were not located in the Hodgson Brook watershed, the results provide insight into the incidence and potential significance of bird and wild animal species as sources of fecal pollution. Birds and wild animals were suspected to be important sources of bacterial contamination in Hampton Harbor. An *E. coli* ribotyping study was initiated to determine the most significant sources of bacterial pollution in the watershed. Jones and Landry (2003) obtained *E. coli* isolates from 20 different potential source species in the Hampton Harbor watershed, including humans, livestock, pets, wildlife and avian species. Water samples from the Harbor were collected during all seasons and under both dry and wet conditions. Source species were identified for 391 *E. coli* isolates. The source species identifications for water isolates from Hampton Harbor were as follows: 26% humans, 15% wild animals, 7% birds, 8% livestock, 4% pets and 40% unidentified. Wild animal species accounted for 14-17% of ribotyped isolates that were identified during wet and dry weather. The most commonly identified wild animal species were deer (12%) and coyote (10%). Birds accounted for 7% of ribotyped isolates identified during both wet and dry weather. The most commonly identified avian species were goose (5%) and seagulls (4%). Thus, although humans comprised the largest fraction of identified sources, birds and wild animals accounted for >20% of identified sources in Hampton Harbor.

2.2.3 Impacts of Fecal Borne Microbial Contaminants

Microorganisms that can cause disease (pathogens) can be waterborne, thus, exposure to contaminated surface waters is a public health issue. In the only study of microbial pathogens in stormwater in coastal New Hampshire (Jones, 1998), measurements of the incidence and concentrations of *E. coli* and non-enteric pathogens, *Pseudomonas aeruginosa* and *Klebsiella pneumoniae*, were made from water samples collected from storm drains and the Cocheco River in downtown Dover. The study results showed spatial differences in the bacterial concentrations which suggest different sources and/or survival of the different pathogens, especially between tidal and freshwater areas. Overall, the existence of relationships between some of the fecal indicators and the pathogens was encouraging in terms of use of the indicators for public health assessments. However, the frequently observed higher concentrations of pathogens compared to indicators at some locations, and the general lack of significant relationships between indicators and pathogens in the Cocheco River, suggest that the indicators may not be suitable indices of the two non-enteric pathogens and, possibly, other pathogens.

In 1998, the Gulfwatch program sampled and analyzed blue mussels, *Mytilus edulis*, for bacterial indicators. The results confirm that mussels from a site in North Mill Pond (NHNM), and to a lesser extent other New Hampshire sites, may be exposed to relatively recent pollution associated with fecal contamination, such as sewage and contaminated stormwater pipe effluent (Table 4) (Jones and Landry, 2000). In addition, only North Mill Pond among the sampled sites had fecal coliform concentrations in water samples that exceeded the state guidelines for approved shellfish waters. As stated previously, the DES Shellfish Program has closed shellfish beds for harvesting in North Mill Pond. The potential sources of contamination have yet to be identified by the Shellfish Program, although there is evidence that illicit discharges are present in the stormdrain systems around North Mill Pond. In addition to microbial pathogens, other contaminants may also be a concern and potentially limit shellfish harvesting. According to the Center for Watershed Protection (2003a), shellfish closure is almost certain in watersheds containing more than 20% impervious cover.

Table 4 Fecal Bacteria Concentration in Water and Mussel Tissue Samples from 1998 Gulfwatch Sites

			Water Samples			Mussel tissue	
Site name	Location	Sample Date	Fecal coliforms cfu/100ml	*E.coli* cfu/100ml	Enterococci cfu/100ml	Fecal coliforms MPN/100g	*E.coli* MPN/100g
MECC	Clark Cove	9/24/94	-	-	-	400	<200
NHSS	PSNH	9/24/94	-	-	-	900	210
NHLH	Little Harbor	9/27/94	<1	<1	<1	80	20
NHNM	North Mill Pond	9/27/94	24	23	1	900	500
NHDP	Dover Point	9/27/94	13	13	7	300	110
NHGP	Gypsum plant	9/27/94	8	5	1	80	40

Source: Jones, S.H. and N. Landry. 2000. *The New Hampshire Gulfwatch Program: 1998.* NH Department of Environmental Services and the Gulf of Maine Council, Concord, NH.

It is difficult to find answers to the question of pathogens and disease incidence associated with stormwater runoff because of the incompleteness of most studies on stormwater runoff and the historical (prior to ribotyping and other microbial source tracking technologies) inability to differentiate between human and non-human sources of contaminants present in surface waters (Jones, 1999). The State of New Hampshire standards on water quality are the benchmarks by which all bodies of water within the state are measured. The intended use for the water needs to first be established before a particular body of water can be assessed since there are different standards for shellfish harvesting and swimming. In both cases the standards are determined for public health and safety. Measuring for both fecal indicators and pathogenic bacteria in urban stormwater drainage systems could help prioritize sources of fecal pollution that may be more significant because of the confirmed presence of microbial pathogens.

There are many microorganisms that are documented human pathogens, many of which have been detected in surface waters and shown to be associated with stormwater runoff (Jones, 1999; Geldrich, 1996; O'Shea and Field, 1992; Pitlik et al., 1987). However, no measurements of microbial pathogens have been made in Hodgson Brook or North Mill Pond and only a few studies of bacterial pathogens in New Hampshire estuary waters have been conducted (Jones and Summer-Brason, 2001; Jones 1998).

2.3 Trace Metals and Toxic Organic Chemicals

Toxic substances are materials capable of producing adverse physiological effects on biotic populations and their ecosystems. Certain chemicals have been identified as toxic substances. They include polyaromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), pesticides (e.g. DDT) and trace metals such as mercury and lead. Whereas some of these chemicals occur in nature, many of them are solely of human origin and all of the toxic chemicals of environmental concern have been discharged from human activities into nature at levels well in excess of any natural processes.

Waterways that lie in close proximity to urban or industrialized areas are often polluted with toxic substances. Once a toxic substance enters the natural environment it can persist for long periods of time in sediments, water and living tissues, e.g. fish and shellfish. Many toxic chemicals adhere to sediments that settle to the bottom of the water body, creating a reservoir for toxic substances. Some toxic chemicals, especially PAHs, are carcinogenic, other chemicals may be mutagenic and all of them can be toxic to biota. These factors make it difficult to manage toxic chemicals because they can resurface years after initial contamination occurs or be biomagnified through tropic levels.

Jones and Gaudette (2001) concluded that present day loading rates of trace metals in New Hampshire coastal rivers are often greater during wet weather/runoff events than during dry weather. The dry weather loading of both metals and bacteria is likely the result of illicit connections present below the surfaces of urban areas in coastal communities, especially older areas that have leakage from sewers into storm drains (Jones and Gaudette, 2001). Loading associated with stormwater runoff probably reflects what is washed from impervious surfaces into storm drains, including contaminants like mercury (Hg) that may come from both dry and wet atmospheric deposition.

Information and data on toxic contaminants are only available for the Pease International Tradeport and the North Mill Pond portions of the watershed. The Air Force and the PDA have conducted water quality monitoring in Grafton and Newfields Ditches. The monitoring approach has been to conduct initial monitoring in these areas to assess contaminant levels, perform remediation strategies, then conduct follow-up monitoring to determine new conditions. The PDA, per requirement of their National Pollutant Discharge Elimination System (NPDES) permit, continues to collect monthly surface water samples from Grafton Ditch after a qualifying rain event begins (> 0.1 in., ≥72 h. after previously measurable precipitation event). Samples are analyzed for biological oxygen demand (BOD), surfactants, oil/grease, iron, zinc, lead, nickel, and cyanide. The PDA reports these monthly results to the EPA in discharge monitoring reports (DMR). Monthly figures are checked to ensure they are within state standards, but there have been no published comparisons of historical data or conclusions about the improvement of water quality. Permit limits for surfactants have been exceeded in Grafton Ditch. Using NPDES Method 5540 C Anionic Surfactants as MBAS, the PDA measured and reported levels to DES that exceeded the allowable surfactant levels at outfall 004, Harvey Creek, which drains into Grafton Ditch.

Grafton and Newfields Ditches are also monitored annually per the USAF Long Term Monitoring Plan. Newfields Ditch is monitored for groundwater and Grafton Ditch for surface water and sediments. Grafton Ditch was sampled for volatile organic carbons (VOCs), semi-volatile organic carbons (SVOCs), pesticides, herbicides, PCBs, PAHs, dissolved metals and total metals. Results from the Long Term Monitoring are published in annual survey reports published by the USAF each April. There has been no further study looking at the effects of nonpoint source toxic chemical contamination within the Hodgson Brook watershed.

At North Mill Pond, one study (ANMP, 1998) reported concentrations of toxic organic chemicals and trace metals in the pond sediments during 1997, although no more recent data are available. The ongoing NH Gulfwatch program has measured levels of toxic organic chemicals and trace metals in blue mussel tissue from the Maplewood Avenue Bridge in 1998, 2000 and 2002. Finally, the National Coastal Assessment (NCA) Program sampled sediments in the pond in 2002 for analysis of toxic organic chemicals and trace metals, and will collect other sediment samples near the mouth of Hodgson Brook in 2004 and 2005. NCA data will become available over the next several years.

2.3.1 Present Status for Toxic Contamination in Mussels in North Mill Pond

Mussels and other bivalve shellfish have been used in many monitoring programs throughout the world to indicate biological exposure to toxic chemical pollutants. Bivalve shellfish are good indicator species because they are sedentary, filter large volumes of water throughout their bodies and do not metabolize organic pollutants. In New Hampshire waters there is one site that is part of the NOAA Mussel Watch program and the state participates in Gulfwatch, a regional Gulf of Maine mussel monitoring program.

Since its establishment in 1998, the New Hampshire Gulfwatch Program uses the blue mussel, *Mytilus edulis*, as an indicator for habitat exposure to toxic organic and trace metal contaminants. The 1998 program concluded that elevated levels of some toxic chemicals in North Mill Pond are evident (Jones and Landry, 2000). The individual PAH compounds detected were examined to determine if oil pollution was a potentially significant source. In North Mill Pond, higher molecular weight and non-alkylated PAHs in mussels were common. These data suggest that PAHs may be from pyrogenic sources or are the result of weathering/degradation of petroleum sources (Table 5). Typically low molecular weight (smaller) PAHs that are associated with fresh oil spills are degraded more rapidly in the environment by indigenous microorganism as compared to high molecular weight PAHs. Pyrogenic byproducts tend to have higher molecular weight PAHs since the lower molecular weight PAHs burn first during combustion. The presence of higher molecular weight PAHs may reflect ongoing sources or simply the long-term persistence of PAHs discharged in the past to North Mill Pond. The spatial distribution of contaminants in New Hampshire mussels showed North Mill Pond to have the highest concentrations of all three types of organic contaminants (PAHs, PCBs, chlorinated pesticides) among all sites sampled in 1998, and this is cause for concern (Figures 1, 2 and 3).

Table 5 PAHs Detected at NH Gulfwatch Site NHNM in 1998

	Mussel tissue					Sediment
Sample I.D.	NHNM 1N	NHNM 1N	NHNM 2N	NHNM 3N	NHNM 4N	#1 NMP
		duplicate				
Naphthalene	<7	<7	<7	<7	<7	ND*
1-Methylnaphthalene	<8	<8	<8	<8	<8	-
2-Methylnaphthalene	<8	<8	<8	<8	<8	ND
Biphenyl	<6	<6	<6	<6	<6	-
2,6-Dimethylnaphthalene	<8	<8	<8	<8	<8	-
Acenaphthylene	<5	<5	<5	<5	<5	ND
Acenaphthene	<5	<5	<5	<5	<5	ND
2,3,5-Trimethylnaphthalene	<10	<10	<10	<10	<10	-
Fluorene	<6	<6	<6	<6	<6	ND
Phenanthrene	15	14	18	13	11	2700
Anthracene	<6	<6	6	<6	<6	540
1-Methylphenanthracene	<9	<9	<9	<9	<9	-
Fluoranthene	111	105	121	107	99	4600
Pyrene	103	96	113	101	92	4600
Benzo(a)Anthracene	42	39	46	41	36	1600
Chrysene	82	76	88	77	73	1800
Benzo(b)Fluoranthene	80	75	86	86	71	2400
Benzo(k)Fluoranthene	53	49	56	55	41	990
Benzo(e)Pyrene	71	66	79	73	65	-
Benzo(a)Pyrene	27	26	33	28	23	1800
Perylene	26	24	28	29	26	-
Indeno(1,2,3,4-cd)Pyrene	23	20	23	22	20	960
Dibenz(a,h)Anthracene	<4	<4	<4	<4	<4	710
Benzo(ghi)Perylene	25	22	24	24	18	920
Total	658	611	721	656	575	23,620

*Note NHNM is North Mill Pond

Sources: Jones, S.H. and N. Landry. 2000. *The New Hampshire Gulfwatch Program: 1998.* NH Department of Environmental Services and the Gulf of Maine Council, Concord, NH.
Advocates of the North Mill Pond (ANMP). 1998. *The state of the North Mill Pond, Portsmouth, NH.* A report to the NH Estuaries Project, Portsmouth, NH.

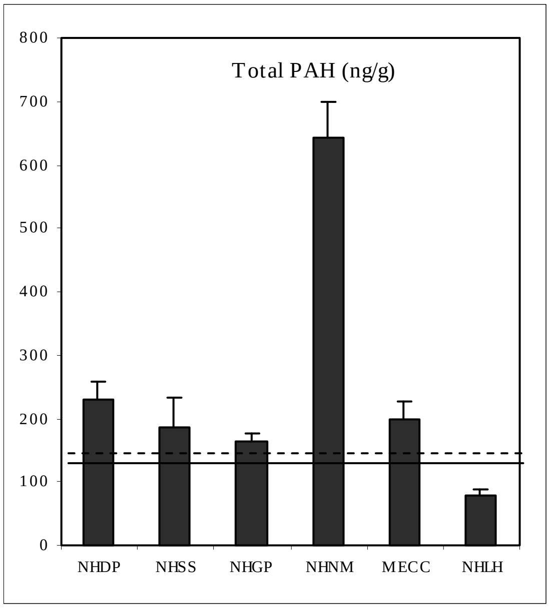


Figure 1 Distribution of Total PAH Tissue Concentrations in Mussels at NH Gulfwatch Stations, 1998

* Note NHNM = North Mill Pond

Source: Jones, S.H. and N. Landry. 2000. *The New Hampshire Gulfwatch Program: 1998.* NH Department of Environmental Services and the Gulf of Maine Council, Concord, NH.

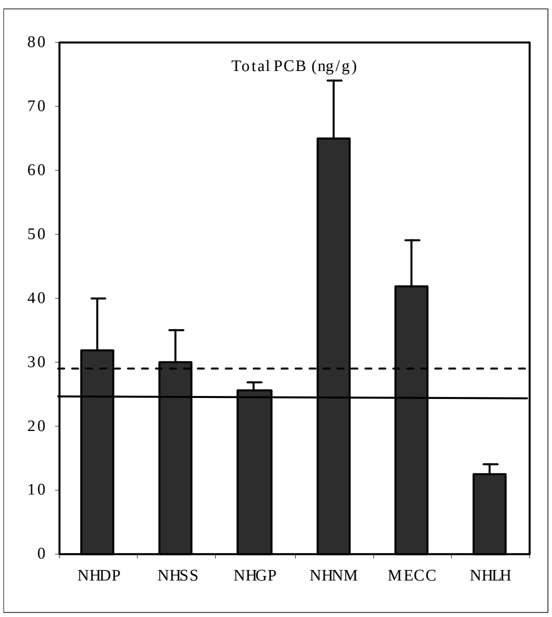


Figure 2 Distribution of Total PCB Tissue Concentration in Mussels at NH Gulfwatch Stations, 1998

Source: Jones, S.H. and N. Landry. 2000. *The New Hampshire Gulfwatch Program: 1998.* NH Department of Environmental Services and the Gulf of Maine Council, Concord, NH.

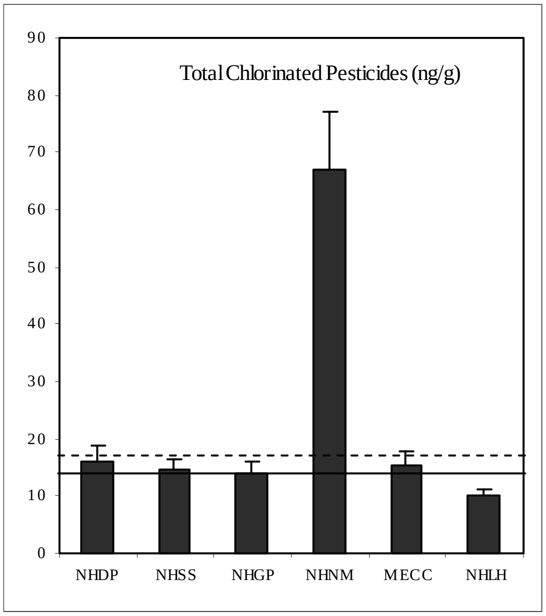


Figure 3 Distribution of Total Chlorinated Pesticides in Mussels at NH Gulfwatch Stations, 1998

Source: Jones, S.H. and N. Landry. 2000. *The New Hampshire Gulfwatch Program: 1998.* NH Department of Environmental Services and the Gulf of Maine Council, Concord, NH.

2.3.2 Historic Trends and Present Status for Contamination in Sediments

Sediments were sampled from 11 sites in North Mill Pond during the ANMP 1997 survey of the pond (ANMP, 1998). Toxicity equivalency factors were obtained from the National Oceanic and Atmospheric Administration (NOAA, 1999). Only one metal, mercury (Hg), exceeded the Effects Range Medium (ER-M) level (0.71 mg/g DW). This occurred at only one site, NMP-02, located near the Bartlett Street inlet to the pond. Concentrations of all other metals were below ER-M levels, but were often above Effects Range Low (ER-L) levels. Individual PAH compounds (17 total) frequently exceeded ER-L limits, although ER-M limits were exceeded in only 3.5% of the samples analyzed. Dibenzo anthracene consistently exceeded ER-M standards. However, the repetitive nature of reported values within samples for individual PAHs draws into question the validity of the data received from the analytical lab. New measurements are needed to confirm these initial results.

The EPA has classified areas on the former Pease Air Force Base as Areas of Concern (AOC) and the USAF has conducted monitoring, remediation and follow-up monitoring activities. Both Newfields and Grafton ditches were classified as AOC by the US Environmental Protection Agency (EPA) in 1993 and the Pease Air Force Base as a Superfund site. Prior to classification the ditches were under surveillance by the USAF to identify the levels of contamination, and the first preliminary sampling occurred between 1984 and 1985. During this time Grafton Ditch was classified as having moderate contamination due to elevated concentrations of toxic organic compounds and oil and grease which were detected at one sediment sampling point (Weston, 1994). Surface samples contained no detectable toxic organic compounds (TOX) or oil and grease.

The USAF Installment Restoration Program (IRP) conducted by Weston identified contaminants in surface waters and sediments of Newfields Ditch and Upper Grafton Ditch. Surface water and sediments were collected for analysis of toxic organic chemicals and metals. The IRP investigation of Grafton Ditch began in 1988 and continued until 1992. During this investigation sediment and water samples were taken, measured and compared with DES surface water criteria and NOAA Effect Range Low values (ER-L) for sediments. This investigation of the ditch found surface water samples exceeded DES surface water quality criteria for benzene, toluene, ethylbenzene, xylenes, 2-methylnapthalene, 4-methylphenol, bisphthalate, phenol, aluminum, copper, barium, boron, calcium and silicon (Weston, 1994). Sediment samples exceeded NOAA ER-L criteria for diethyl ether, di-n-butyl phthalate, naphthalene, DDE, TPH, arsenic, lead, mercury, nickel, aluminum, vanadium, boron, cobalt, iron, manganese, beryllium, and selenium. Since the DES does not have sediment criteria they use NOAA guidelines. The NOAA guidelines cannot be enforced by the DES unless a link can be made between the discharge of groundwater in contaminated soils and the pollution of surface waters. Exceedances of either groundwater or surface water quality standards are one example of how NOAA standards can be enforced by the DES.

Under the IRP investigation, Newfields Ditch was also classified with moderate contamination due to elevated concentrations of TOX and oil and grease found in sediment samples (Weston, 1994). Weston (1994) sampled both Upper and Lower Newfields Ditch. In Upper Newfields Ditch, surface water exceeded DES surface water quality criteria for bromoform, chlorobenzene, TCE, vinylchloride, aluminum, barium, cobalt, iron, manganese, potassium, silicon, vanadium, boron, cadmium, and thallium. Sediments exceeded NOAA criteria for acetone, carbon disulfide, vinyl chloride, 2-butanone, diethyl ether, toluene, fluoranthene, pyrene, DDT, DDD, DDE and heptachlor. Weston (1994) detected surface water Lower Newfields Ditch above DES surface water quality criteria for chlorobenzene, methylene chloride, 1,4-dichlorobenzene, aluminum, cadmium, iron, copper, zinc, selenium, calcium, silicon, and sodium. Sediment samples in Lower Newfields Ditch exceeded ER-L standards for VOCs and SVOCs. Investigations found similar pesticides, HHCs, AHCs, PAHs and metals common in both sites although no further investigation of similarities has been conducted. Remediation of contaminated sites has occurred in both Grafton and Newfields ditches (see Sections 2.42, 2.43, and 2.44).

Presently, the USAF has set forth an ongoing investigation, the Long Term Monitoring Plan, to determine the environmental status of the drainage basins within the Tradeport with regard to historical contamination that had been identified as public health or ecological risks through the CERCLA program. Designated sites are monitored throughout the year and an annual report is published. Grafton Ditch is the only site within the Hodgson Brook watershed that is monitored as part of the Long Term Monitoring Plan (MWH Americas, Inc., 2002). Routine monitoring of six stations in Lower Grafton Ditch revealed arsenic, lead and PAH concentrations present in the sediment (MWH Americas, Inc., 2002).

Pesticides, mainly DDT and metabolites (4,4-DDD) were the most frequently detected pesticide compounds at Grafton Ditch in the year 2000 samples. Also in 2000, the samples exceeded arsenic and lead concentrations per NOAA ER-L standards. There was a decreasing PAH trend in sediment samples. In 2001, toxic chemicals were detected, but only arsenic and lead were found to exceed NOAA criteria in Lower Grafton Ditch. The results also show a decreasing PAH trend in sediment samples of Lower Grafton Ditch since 1998 (MWH Americas, Inc., 2002). Sampling will continue on an annual basis.

The results of water and sediment measurements are currently being interpreted in the context of natural background levels and ongoing pollution sources. Most toxic organic chemicals are either only made by humans or are present in the environment at elevated levels as a result of human activities. Thus, detection of these in water or sediments is an indication of pollution. However, all trace metals are found in nature, and occur at concentrations in the absence of pollution based on bedrock composition, groundwater and surface water chemistry, and other factors. DES and the Air Force conducted several studies to determine background levels of metals for comparison to levels detected at AOCs. Based on these data, some of the elevated concentrations detected for trace metals, even when they exceeded standards, are not considered to be a result of pollution because of the expected natural background levels. For example, numerous recent studies are showing arsenic to be present in groundwater, surface waters and sediments in southeaster New Hampshire at elevated concentrations (New Hampshire National Coastal Assessment Program, unpublished).

2.3.3 Status and Trends for Atmospheric Contamination and Deposition

Sediment contamination is not limited to past contamination or runoff; it can also be influenced by atmospheric deposition. A study was conducted in Eliot, ME, by the DES (2000) to investigate the deposition of airborne particulate matter in a residential community on the Piscataqua River during 1999. The Piscataqua River shoreline has two electric generating stations owned and operated by Public Service of New Hampshire (PSNH), the Newington and Schiller stations. Emissions from the stacks were monitored for total suspended particulate concentrations, sulfur dioxide concentrations, and metals. A local advocacy group, Clean Water Action (CWA, 2000) also conducted a simultaneous study with the DES in Eliot, ME. All sample analyses during the study periods were compared to the federal National Ambient Air Quality Standards (NAAQS) and New Hampshire pollution standards. It was hoped that measuring emission levels would provide insight towards sources of soil contamination downwind of the plants. The results showed elevated levels of arsenic in soils, a common observation in recent studies in the region. CWA states that no power plant in the state of New Hampshire is regulated, nor even required to test for, toxic air emissions such as arsenic and other heavy metals (CWA, 2000). Residents downwind of these plants have for years been subject to the effects of particulate fall out, stack downwash and fugitive dust, and PSNH has never denied that these problems exist or that the plants are a source of pollution (CWA, 2000). Even though the plants did not exceed any limits or federal standards for air quality, they are still considered to be a potential source for particulate matter.

Particulate matter in the atmosphere is a major contamination concern in the area, particularly among Seacoast residents. Although the results of a recent study by the DES showed particulate levels at both the Newington and Schiller stations were consistent with state and federal requirements, there have been no other specific particulate matter sources identified in the Seacoast area despite a variety of air pollution emissions existing. Possible sources include vehicles, coal dust, and emissions from numerous local sources. The DES (2000) and CWA (2000) studies both convey the important effect of atmospheric deposition on soils in the area. Air samples were analyzed for total suspended particles (TSP) and sulfur dioxide (SO_2). All monitored levels of TSP and SO_2 during the study were below the most recent federal National Ambient Air Quality Standards and state air standards for the pollutants (DES, 2000). The highest TSP concentration measured was 44 micrograms per cubic meter ($\mu g/m^3$) where the most recent federal and state standard was 260 $\mu g/m^3$. The greatest particulate matter impacts were from fugitive coal dust emissions (DES, 2000). The highest 3-hour average SO_2 level monitored was 55 ppb, which is much lower than the federal and state 500 ppb standard (DES, 2000). Eliot, Maine is close to the Hodgson Brook watershed and the researchers' findings and suggestions should be considered in the monitoring of Hodgson Brook. Meteorology (wind direction, speed, and precipitation) was found to be an important component for emissions impact to surrounding areas. Thus, meteorological conditions may be important in determining whether the local power stations and other industries are sources of pollution to the Hodgson Brook watershed.

PSNH and other industries that have significant emissions to the atmosphere are potentially important local source of toxic contaminants and other deleterious substances. In 2002, the New Hampshire Clean Power Act (HB 284) was signed into law. The Act addresses sulfur dioxide, nitrogen oxide, mercury, and carbon dioxide air pollutants and their impact. HB 284 requires sulfur dioxide emissions be reduced by 87% by 2006, nitrogen oxide emission reduction of 70% by 2006, a reduction in carbon dioxide emissions, and that a cap for mercury emissions be recommended to the Legislature by the DES by early 2004 (http://www.des.state.nh.us/ard/CleanPowerAct.htm). The Act also includes innovative new incentives to encourage PSNH to comply with the emission reductions by offering credits for emission reductions under three years (http://www.des.state.nh.us/ard/CleanPowerAct.htm). Air quality monitoring in the Seacoast (Schiller and Newington stations) has shown decreases since 1998 in hydrochloric acid, sulfuric acid, and total emissions (Appendix 15).

2.3.4 Sources of Toxic Contaminants

Many of the contaminants still detected at the Tradeport were introduced during the 1950's and 60's when Pease Air Force Base was operating. Pesticides were used to control weeds, insects and other organisms considered to be pests. Some of the pesticide compounds are thought to have originated from general base usage or from agricultural activities prior to the base's construction (Bechtel Environmental Inc., 2000). Several pesticides, especially chlordane, were sprayed on selected housing units in the base to control insects. Meticulous records of application, frequency, and location were kept by the Air Force since spraying was paid for by the US government. Since application of pesticides was done according to established dose/application guidelines, the US Air Force was not responsible for cleaning contaminated sediments found at sites that had previously been subjected to pesticide application and were found in the 1990's to be harmful to both human and ecological health. The CERCLA program excluded the USAF from cleanup of pesticides, airborne related contamination, or any ubiquitous problems which were not site related. Since, at the time, there were no regulations against certain pesticides, holding the Air Force responsible just because they have records of application has not happened. Today companies that wish to develop on contaminated soils in the Pease International Tradeport must pay to remove or manage contaminated sediments found on site.

A refuse-to-energy facility was operated at Pease from 1982-1987 during which time municipal solid waste and trash were incinerated (M.Daley, personal communication). It is thought that the combustion of solid waste may have resulted in higher levels of metals and toxic organic chemicals in nearby soils. The facility was located near the intersection Exeter Street and New Hampshire Avenue.

Between the years 1994-1997, Grafton Ditch was found to be filling with sediment and silt runoff and as a result was not draining properly. The United States Air Force conducted wetland restoration efforts to promote drainage in Grafton Ditch and tested for toxic contaminants used by the Air Force prior to its closing. Although the sources of contamination have been eliminated, some chemical contaminants in soils, sediments and groundwater may be continued sources of pollution to surface waters and biota due to their persistence in the environment.

In the North Mill Pond watershed blue mussels, *Mytilus edulis*, were sampled at the Maplewood Street Bridge by the Gulfwatch program to assess the current status of toxic chemicals in the aquatic biota (Jones and Landry, 1998). The results showed levels of PCBs, PAHs and chlorinated pesticides in mussels were significantly higher than at other sites in coastal New Hampshire. Blue mussel tissue results were compared to sediment data reported by ANMP (1998). Correlations between the two suggest the elevated lead (Pb) concentrations in mussels from North Mill Pond are probably associated with Pb contaminated sediments in the pond (Tables 6, 7). The sources of the toxic organic chemicals in mussels are not known and cannot be attributed to any sources at Pease International Tradeport without further studies.

Table 6 Tissue Metal Concentrations for NH Gulfwatch Stations, 1998

Station	Ag	Al	Cd	Cr	Cu	Fe	Hg	Ni	Pb	Zn
NHDP	ND	202±39	2.80±0.28	2.95±0.06	6.06±0.69	385±50	0.97±0.05	1.70±0.20	3.02±0.31	130±14
NHGP	ND	175±49	1.92±0.52	2.08±0.56	4.70±1.27	358±103	0.86±0.09	1.35±0.24	3.32±0.56	111±25
NHLH	ND	162±31	2.42±0.10	2.75±0.97	5.12±0.33	400±45	1.00±0.05	1.72±0.17	4.65±0.37	105±17
NHNM	ND	260±54	1.98±0.37	2.32±0.43	6.55±0.60	482±99	0.79±0.12	1.24±0.20	5.18±1.45	135±21
NHSS	ND	192±34	2.25±0.51	2.30±0.18	6.12±0.49	385±38	1.08±0.10	1.45±0.24	3.15±0.48	128±10
MECC	ND	298±64	2.08±0.13	3.18±0.69	7.20±0.67	528±80	0.82±0.11	2.32±1.08	5.75±0.70	135±24
Geometric mean	<p.1	206±1	2.20±1.24	2.52±1.28	5.85±1.23	413±1	0.91±1.16	1.57±1.32	4.00±1.35	122±1

*Note NHNM= North Mill Pond

Source: Jones, S.H. and N. Landry. 2000. *The New Hampshire Gulfwatch Program: 1998.* NH Department of Environmental Services and the Gulf of Maine Council, Concord, NH.

Table 7 Tissue Organic Contaminant Concentrations from Mussels Collected by NH Gulfwatch, 1998

STATION	∑PAH	∑PCB	∑PEST17	∑DDT6	∑OPEST11
NHGP	164±13	25.5±1.5	14.1±1.9	9.63±1.52	4.50±0.82
NHLH	78±11	12.5±1.7	10.2±0.8	5.01±0.46	5.16±0.52
NHSS	187±46	30±5	14.6±1.9	9.59±1.25	5.00±1.07
NHDP	230±29	32±8	16.1±2.6	11.6±2.8	4.55±0.59
NHNM	644±55	65±9	67±10	62±9	5.80±1.28
MECC	200±26	42±7	15.4±2.3	11.6±2.0	3.78±0.30
Geo. mean	210±2	31±2	18.7±1.9	13.0±2.3	4.7±1.2

*Note NHNM= North Mill Pond

Source: Jones, S.H. and N. Landry. 2000. *The New Hampshire Gulfwatch Program: 1998.* NH Department of Environmental Services and the Gulf of Maine Council, Concord, NH.

Sources of toxic substances are typically from industrial, agricultural, and domestic/urban activities. Wastes from these activities can enter the environment via point and nonpoint source pollution. Nonpoint sources enter waterbodies from runoff or atmospheric deposition and are often more difficult to control than point sources. Much of the mercury (Hg) and other toxic substances in atmospheric deposition in New Hampshire are suspected to come from both local sources and the Midwestern United States where industry emits mercury into the atmosphere from coal combustion, smelting, and waste incineration (DES, 2000). The burning of fossil fuels is also the main cause of acid deposition. A 1998 study issued by the Northeast States and Eastern Canadian Provinces, estimates that 47% of the mercury deposited in the northeast United States originates in the northeast and 23% comes from the global atmospheric reservoir (DES, 2000). Locally, wet and dry atmospheric deposition has been identified as a significant source of mercury contamination to the area based on measurements made in New Castle. Annual deposition based on weekly sample analyses during 2000 and 2001 showed higher amounts of Hg deposited at New Castle, New Hampshire compared to an inland site (Laconia, NH).

Mercury levels within the state are a concern. A recent study of Hg suggests that loons living in the southwest corner of New Hampshire contain the highest levels of mercury in their tissues than other areas in the US (Evers, 2001). The NH Department of Health and Human Services has issued consumption warnings for many species of both freshwater and marine fish as well as shellfish. In 1998 a state-wide mercury reduction strategy was implemented to reduce 50% of mercury release by 2003. According to the DES the long term goal of the plan is to eliminate all manmade mercury releases within the state.

The levels of toxic substances in the Hodgson Brook watershed have not been analyzed except for an Air Force Base-wide survey conducted at the Pease International Tradeport in 2001. The study showed a decreasing PAH trend in sediment concentrations in Lower Grafton Ditch. Elevated arsenic and lead levels were also found, but their levels relative to background concentrations are under investigation.

In March 2002 a gasoline spill flowed from a gas station on the Rt. 1 Bypass through a storm drain and into the North Mill Pond (DeConto, 2002a, 2002b). The spill was cleaned up with hydrophobic pads which absorb oil but not water. The spilled gas was tested by Public Service of New Hampshire (PSNH) for polychlorinated byphenyls (PCBs). The spilled gas was found to contain no PCBs and no further analysis of the spilled material took place.

The results of analysis of the Gulfwatch blue mussel samples serve to provide a baseline for biological exposure to toxic chemicals in North Mill Pond (Tables 5, 8 and Figures 1, 2). Toxic organic chemicals in mussel tissue measured in 1998 from North Mill Pond were greater than 5 times higher than the next highest concentration and greater than 12 times higher than the lowest concentrations of all New Hampshire sample sites. The elevated concentrations of organic contaminants at NHNM (Maplewood Avenue Bridge) suggest sources of the compounds may have been or are still present in North Mill Pond. Historically there was a substantial amount of industry in the North Mill Pond watershed. Sediments should be analyzed since they have the potential to act as a vector for historical pollutants. Jones (2000b) identified resuspension of sediments as a potential source for toxic metals and organic contaminants to aquatic ecosystems.

Table 8 Polychlorianted Dibenzodioxin and Dibenzofuran Concentrations in Mussels at NH Gulfwatch Sites, 1998

Congener	NHNM
	1998
Non-ortho	
PCB-77	36
PCB-126	6
PCB-169	0.76
Mono-ortho	
PCB-105	420
PCB-114	20
PCB-118	1200
PCB-156	170
PCB-189	10
Di-ortho	
PCB-170	120
PCB-180	320
Total	**2303**

Congener	TEF	NHNM
		1998
Non-ortho		
PCB-77	0.0005	0.0180
PCB-126	0.1	0.6000
PCB-169	0.01	0.0080
Mono-ortho		
PCB-105	0.0001	0.0420
PCB-114	0.0005	0.0100
PCB-118	0.0001	0.1200
PCB-156	0.0005	0.0850
PCB-189	0.0001	0.0010
Di-ortho		
PCB-170	0.0001	0.0120
PCB-180	0.00001	0.0032
Total		**0.90**
(pg/g wet wt)		

Dioxins	NHNM
	1998
T4CDD - Total	12
2,3,7,8	<0.2
P5CDD - Total	0.6
1,2,3,7,8	<0.4
H6CDD - Total	3.1
1,2,3,4,7,8	<0.6
1,2,3,6,7,8	<0.6
1,2,3,7,8,9	<0.6
H7CDD - Total	7.3
1,2,3,4,6,7,8	2.9
O8CDD	16
Furans	
T4CDF - Total	7.1
2,3,7,8	1.3
P5CDF - Total	2.6
1,2,3,7,8	<0.4
2,3,4,7,8	<0.4
H6CDF - Total	0.9
1,2,3,4,7,8	<0.6
1,2,3,6,7,8	<0.6
2,3,4,6,7,8	<0.6
1,2,3,7,8,9	<0.6
H7CDF - Total	0.9
1,2,3,4,6,7,8	<0.7
1,2,3,4,7,8,9	<0.7
O8CDF	0.8
TEQ -Total*	**0.18**

*TEQ= Toxic Equivalency Concentration. Calculations using WHO international Toxic Equivalency Factors (TEF).
Source: Jones, S.H. and N. Landry. 2000. *The New Hampshire Gulfwatch Program: 1998.* NH Department of Environmental Services and the Gulf of Maine Council, Concord, NH.

2.3.5 Biological Impacts and Public Health Risks

Initial uptake of toxic chemicals by organisms can occur directly from the water column, via consumption of contaminated biota or from ingestion of sediment and other suspended particles. Once these chemicals have entered the biological components of an ecosystem, toxic substances are passed among organisms and eventually up through the different trophic levels of the food web. By traveling through trophic levels, some chemicals have the potential to increase in concentration and can reach potentially toxic concentrations at the top of the food chain. There are several factors that can affect the impact of a particular chemical on an organism. These include mode of exposure, life stage, and vulnerability of an organism due to health and life history and the duration of exposure to the chemical. The adverse impacts on biological communities due to the presence of toxic substances can be difficult to determine. This is especially true if the only data available are for individual species and tests are run in laboratories, since controlled environments are not always representative of the natural environment.

In New Hampshire, fish consumption advisories have been issued by the Department of Health and Human Services (DHHS) and Division of Public Health Services (DPHS). These departments analyze fish tissue data to determine if a public health risk may be associated with consumption. If the DHHS determines any risks they decide on the appropriate advisory. Currently there are fish consumption advisories within the state because of two toxic chemicals. There is a general ban against the consumption of any freshwater fish due to the concern for mercury (DES, 2000). In 1991, a study conducted by the US Food and Drug Administration and DHHS determined that lobster tissues from the Great Bay Estuary were contaminated with polychlorinated biphenyls (PCBs). Based on risk assessment, it was concluded that there might be an increased cancer risk for individuals who consume approximately 50 lobsters per year and an advisory was issued (DES, 2000). There are also consumption warnings for PCBs in lobster tomalley and bluefish. There are also mercury consumption warnings currently in effect for several marine fish species and shellfish in general. There is concern that the same atmospheric and land uses that influence the contaminants in New Hampshire estuaries and coastal waters could also negatively influence organisms in the Hodgson Brook watershed.

The DES Hodgson Brook Biomonitoring Project (unpublished) and Weston (1992) both sampled macroinvertebrates to assess stream health. DES identified over 300 individual organisms from the Cate Street Bridge and determined the two most common crustaceans were *Cheumatopsyche* (sp.) and *Caecidotea* (sp.) (Appendix 12). Presently, there is no published report on this monitoring effort that interprets stream health from these data. The US Air Force contracted Roy F. Weston, Inc. to provide an environmental assessment of the Grafton Drainage Ditch using surface water, sediment, and macrobenthos sampling, which occurred June 18-19, 1991 (Weston, 1992). A combined total of 3,257 benthic macroinvertebrates representing 47 taxa were collected in 25 samples from Grafton Ditch drainage area. Most of the organisms found were intermediate tolerance species and indicate moderate water quality.

2.4 Historical and Present Air Force Base Related Contaminants

When Pease was an operating U.S. Air Force Base it generated waste fuels, oils, lubricants, solvents and protective coatings. Some of these materials contaminated soils, groundwater, surface water and sediments. As a result there have been concerns for public and ecological health due to past contamination and the use of toxic material. The Department of Defense Installation Restoration Program (IRP) was responsible for identifying the locations of releases from past disposal sites and minimizing associated hazards to human health and the environment (Weston, 1993; Weston, 1994; Gutro, 1997; Bechtel Environmental Inc., 2000; MWH Americas, Inc., 2002). The IRP identified contaminants in the area surrounding Grafton and Newfields Ditches. Subsequently, Pease Air Force Base was closed on March 31, 1991. After the Air Force Base closure, Pease International Tradeport and other sites around the Pease International Tradeport were monitored for various contaminants. The other sites were monitored to determine the background levels for local water/soils. Remediations of contaminated sites in the former Air Force Base were conducted only after background levels at other sites were identified. Since remediation, Pease International Tradeport continues to be monitored.

2.4.1 Sources of Air Force Related Contaminants

The IRP identified contaminants in Zone 3, which is situated near Grafton and Newfields Ditches. Historically Zone 3 was used by the Air Force for most of the repairs and maintenance of aircraft. Common contaminants in Zone 3 include gasoline, diesel fuel, TCE, 1,1,1-TCA, PCE, and carbon tetrachloride (Weston, 1993). The primary sources of contamination to surface water quality of Grafton Ditch include: surface water runoff from Landfill 6, Construction Rubble Dump 2, Jet Engine Test Cell (site 34) and runoff from the industrial areas in Zone 3 and 4 (MWH Americas, Inc., 2002). Landfill 6 received domestic and industrial solid waste during the 1970's (MWH Americas, Inc., 2002). According to Weston (1992), the primary contaminants identified there were polycyclic aromatic hydrocarbons (PAHs) and metals. The Construction Rubble Dump 2 received materials such as, asphalt, concrete, plastic, wood, rubber, cloth, wire and metal (MWH Americas, Inc., 2002). The primary contaminants found were PAHs and TDHs (Weston, 1992). Jet Engine Test Cell (site 34) contributed PAHs, metals, and the combustion from aerial fallout to the ditch (MWH Americas, Inc., 2002). Surface water and sediments in upper Grafton Ditch and upper Newfields Ditch were evaluated and results indicated chemicals of concern could pose a risk of adverse effects to either terrestrial or aquatic life at each site (Weston, 1993).

Weston (1993) identified potential sources of water and sediment contamination for Newfields and Grafton Ditches. They suggested that stormwater runoff could carry organic chemicals and metals in solution, or attached to sediments, to the ditches. In particular, operation of the airfield contributed to increased organic compounds and metals. In 1995, the US Air Force selected a cleanup remedy for the primary contaminants which included excavation and off-base disposal of metals and PAH-contaminated sediments from Landfill 6 and the installation of a cap on Construction Rubble Dump 2 (MWH Americas, Inc., 2002). Even though there was no remediation in

Grafton Ditch itself, the removal of contaminants from primary contributors was expected to reduce any negative impacts these sites had on the ditch. Restrictions on groundwater use and long term groundwater monitoring were also issued. Today land uses such as commercial industry (e.g., PDA tenants), residential areas like the Pannaway Manor, and the Interstate 95/Spaulding turnpikes are the major contributors of surface water runoff to Grafton Ditch.

In addition to the monthly monitoring of certain sites on the Tradeport by the PDA and DES, the Bedrock Bioremediation Center at UNH is currently compiling groundwater data from sites throughout the former Pease Air Force Base. The data are primarily from Zone 3, site 32 (Upper Grafton Ditch). The data from the following documents are under analysis by the Bioremediation Center researchers. Specifically, the researchers will be reviewing the volatile organic compounds, major cations and anions, and organic carbon data.

> Record of Decision Site 32/36 (09/95), Pease Air Force Base Long-Term Monitoring Plan Draft Final (06/97), USAF- Installation Restoration Program Pease AFB- Zone 3 Remedial Investigation Report (09/93), Pease Zone 3- First Year Operations Data, Pease AFB IRP Zone 3 1999 Annual Report- Appendix A: Zone 3 groundwater analytical results, Zone 3 Statue Report- Installation of new wells (05-10/99), Pease Zone 3 2000 Annual Report (04/01).

2.4.2 Status and Trends of Air Force Base Related Contaminants in Grafton Ditch

During initial monitoring of the Air Force Base, Weston sampled Upper Grafton Ditch for various contaminants in soils and surface waters. Inorganic analytes and organic compounds were detected in sediments and exceeded NOAA ER-L criteria and maximum background concentrations (Weston, 1993). In surface water, only one SVOC, bis (2-ethylhexyl) phthalate, exceeded DES criteria (Weston, 1993).

In 1997 the PDA and DES sponsored the Grafton Ditch Restoration Project. According to the DES, water quality had been impaired due to sedimentation in the ditch and polluted runoff from paved areas within the Grafton Ditch drainage area. The DES wanted to improve surface water quality in Grafton Ditch. The objective of the project was to create a bio-engineered environment within the boundaries of the existing channel that would provide natural treatment for surface water runoff. Restoration included the meandering of the channel to increase silt and sediment fall out from surface water, planting vegetation, which would uptake nutrients and metals from the soil, and removal of sediment buildup near the culvert. The PDA analyzed water samples from Grafton Ditch to evaluate the effectiveness of the bio-engineered restoration project on the quality of surface water passing through the channel. Restoration was successful and a post-construction monitoring plan was drafted by the PDA. No formal report for this project has been written.

After completion IRP remedial activities, the USAF was required to further monitor sites which exceeded DES criteria and to evaluate the performance of remediation. Sites selected for the Air Force Base-wide sampling program were thought to be at risk of receiving contamination from IRP sites. Grafton Ditch was chosen for further monitoring because its surface waters and sediments were at risk for receiving point contamination from a landfill, construction rubble site, and Test Engine Cell. Under the Long Term Monitoring Plan, samples are collected annually at six permanent monitoring stations in lower Grafton Ditch (MWH Americas, Inc., 2002). The stations are monitored for surface water and sediment qualities. Surface water monitoring includes analyses for VOCs and metals, and sediment is analyzed for metals and PAHs (MWH Americas, Inc., 2002). Sample criteria are based on the DES (Env-Ws 1700) Water Quality Criteria for Toxic Substances and the National Oceanic and Atmospheric Administration (NOAA) Effects Range Low (ER-L) values. The sample criteria serve to represent concentrations that will not be harmful to public health.

In some instances the DES does not have water quality criteria for a particular toxin even though it was detected in samples. Although the DES does not have water quality criteria for toluene, it was the only VOC detected in Lower Grafton Ditch surface water samples on two separate sampling dates, 23 April 2001 and 20 July 2001. In 2000 water samples were found to exceed criteria for metals (iron, copper, lead and zinc), SVOCs, and VOCs per DES Water Quality Criteria for Toxic Substances. SVOCs, mostly phthalate esters, also exceeded DES Water Quality Criteria for Toxic Substances in 1999. It is suspected that construction activities within the Tradeport contributed to their increases (Bechtel Environmental Inc., 2000).

Historical analytical data suggest a continuing pattern of non-detection or low VOC concentrations in the surface water of Lower Grafton Ditch (MWH Americas, Inc., 2002). In 2001 water samples analyzed for metals were found to exceed the DES (Env-Ws 1700) Water Quality Criteria for aluminum, cadmium, chromium, iron, lead and zinc. Comparisons of historical results indicate variability in total metal concentrations between consecutive sampling. In addition to the natural presence of some metals at elevated concentrations, exceedences of criteria and variable concentrations may be attributed to time of sampling, inclusion of fine sediment in samples (MWH Americas, Inc., 2002), oxidation/reduction conditions, biological availability and other water chemistry conditions, and the methods used to analyze the water samples (S. Hilton, personal communication). These factors are especially important considerations for chemicals that are not known to have been discharged at or near the sampling sites. Water samples were analyzed for pH and specific conductance to determine possible relationships with metal mobility. There was no trend found in these measurements, therefore these factors were not considered to be important determinants of metal concentrations.

In 2000, sediment samples from Lower Grafton Ditch exceeded the NOAA ER-L criteria for PAHs, pesticides (DDT and metabolites) and metals (arsenic and lead). In 2001, sediment samples were analyzed for arsenic, lead, silver and PAH. The results for sediment sampling indicate that arsenic had the highest rate of ER-L exceedance, although lead exceeded the NOAA criteria as well. Total PAHs also exceeded criteria, although after reviewing historical data the stations appear to have a decreasing total PAH trend (MWH Americas, Inc., 2002). The monitoring program will continue in the future. Recommendations have been made to improve sampling techniques along with suggested frequency for sampling parameters based on sampling findings. A new long-term performance monitoring program will be developed. It will include annual monitoring of the known contaminants at both Newfields and Grafton Ditches.

Currently, The PDA, per requirement of their National Pollutant Discharge Elimination System (NPDES) permit, continues to collect monthly surface water samples at selected sites in the Tradeport, including Grafton Ditch. Samples are analyzed for biological oxygen demand (BOD), surfactants, oil/grease, iron, zinc, lead, nickel, and cyanide. The PDA reports these monthly results to the EPA in discharge monitoring reports (DMR). DES reviews monthly sample results for violations. One violation for surfactants occurred at Harvey Creek in November 2001.

2.4.3 Status and Trends of Air Force Base Related Contaminants in Newfields Ditch

During the IRP investigation, Newfields Ditch stations were also monitored for surface water and sediments. Surface water monitoring included analyses for VOCs and metals, and sediment was analyzed for metals and PAHs (MWH Americas, Inc., 2002). Sample criteria were based on the DES (Env-Ws 1700) Water Quality Criteria for Toxic Substances and the National Oceanic and Atmospheric Administration (NOAA) Effects Range Low (ER-L) values. The sample criteria serve to represent concentrations that will not be harmful to public health.

In upper Newfields Ditch surface water, inorganic analytes were detected at concentrations above DES criteria (Weston, 1993). These included aluminum, beryllium, cadmium, copper, iron, lead, mercury, and zinc. In sediments, organic compounds (VOCs, SVOCs, and pesticides), inorganic compounds and metals were detected above NOAA ER-L sediment concentrations. The VOCs included 1,2-DCE, acetone, carbon disulfide, TCE, and vinyl chloride (Weston, 1993). The SVOCs were fluoranthene and pyrene. The pesticides included alpha-chlordane, DDT, DDD, DDE, and heptachlor epoxide (Weston, 1993). Inorganic contaminants included arsenic, chromium, lead, mercury, nickel and zinc.

In lower Newfields Ditch surface water and sediments were also collected. In surface water, Weston (1993) found pesticides, DDT and heptachlor epoxide, exceeded DES criteria. Inorganic chemicals in surface waters were also found to exceed DES criteria. In sediments, SVOCs (including PAH) and other organic chemicals were detected. Pesticides found to exceed NOAA criteria included alpha-chlordane, gamma-chlordane, DDT, DDD and heptachlor (Weston, 1993). Nickel, zinc and lead also exceeded NOAA ER-L criteria.

The IRP investigation found Newfields Ditch contained trichloroethylene wastes and traces of raw sewage disposal. Remedial action was taken by the US Air Force to remove contaminated sediments from the ditch. Post remediation sampling found contaminants below a level of concern for health risks.

Under the Long Term Monitoring Plan, Newfields Ditch is monitored annually for groundwater contamination. Unlike Grafton Ditch, Newfields Ditch was not chosen for further surface water or sediment monitoring because there are no high risk point pollutants that were identified or that are impacting these mediums.

2.4.4 Impacts and Public Health Risks

Human exposure to environmental contamination is only considered to be a potential public health problem when all elements of an exposure pathway are present. A completed pathway consists of five elements: source, environmental media/transport, point of exposure, route of exposure, and receptor population (US Department of Health and Human Services, 1999). The Agency for Toxic Substances and Disease Registry (ATSDR) was required by law to conduct a public health assessment at every site on the EPA National Priorities List. The evaluations determine if people are being exposed to hazardous substances and, if so, whether that exposure is harmful and should be stopped or reduced. The Pease Air Force Base was put on the National Priorities List in 1990.

Selected sites were sampled for contamination. Both Grafton and Newfields Ditches were sampled for contaminated sediment. In both ditches contaminated sediments were removed and the sites re-tested. According to the EPA Hazardous Substance criteria, all contaminants were found to be below levels of concern for health risk. Since no exposure is occurring, ATSDR declared Grafton and Newfields ditches not to be considered public health hazards. In 1999, the U.S. Department of Health and Human Services stated that there is no exposure in the former Pease Air Force Base drinking water above levels of concern (US Department of Health and Human Services, 1999).

2.5 Nutrients

2.5.1 Historic Trends and Present Status for Nutrients and Dissolved Oxygen

Nutrient loading is an important issue for New Hampshire coastal water tributaries because excess nutrients can lead to eutrophication (Jones, 2000b). Information about nutrient loading in the Hodgson Brook watershed is only available for the area near the mouth of Hodgson Brook and the North Mill Pond. Additional data are needed for the upper portion of the watershed to determine the loading and impacts from nutrient inputs.

The ANMP (1998) conducted a study which documented moderate nutrient loading in North Mill Pond. Jones (2000a) found that ammonium, nitrate and dissolved inorganic nitrogen (DIN) concentrations decreased from an upstream Hodgson Brook site out to the Piscataqua River. Average loading rates for nitrate, ammonium and phosphate were all 2-3x higher at GBW 19 (Hodgson Brook mouth, Bartlett Street) compared to other sites (Jones, 2000a). Jones (2000a) also concluded that storm drains can be sources of elevated concentrations of dissolved nutrients. Jones (2000a) found that nitrate and DIN concentrations were greater during wet weather conditions. The report confirmed that the conditions at GBW 19 are relatively more contaminated than at a site in the upstream portion of Hodgson Brook. Elevated nutrients at sampling sites 8100, Hodgson Brook upstream, and GBW 19 may be associated with illicit sewage discharges. Hodgson Brook sites 8100 and GBW19 should be considered as high priority for follow-up investigation and/or remediation.

Jones (2000a) also found higher levels of dissolved oxygen (DO) concentration during the wintertime compared to the warmer months in North Mill Pond and Hodgson Brook, mostly as a function of colder water having a greater capacity for dissolving oxygen. The state freshwater standard for DO is > 75% saturation in a 16 h period, although only instantaneous, and no 16 hour, measurements have been made in the watershed. The first incident of an instantaneous DO measurement of <75% saturation in the study occurred at GBW 19 (Hodgson Brook inlet, Bartlett Street) in Hodgson Brook on 9/10/99 (Jones, 2000a). The DO level was depressed under conditions of increased runoff during and after rain events, suggesting that stormwater discharges are having an impact on North Mill Pond, although the effects are not acute (Tables 9, 10) (Jones, 2000a). In North Mill Pond, the lowest average percent DO saturation (92.4%) was observed in Hodgson Brook at GBW 19 (Hodgson Brook inlet, Bartlett Street). Low dissolved oxygen is a common impairment of estuarine and marine waters likely caused by inorganic or organic nitrogen loads (http://www.epa.gov).

Table 9 Average Dissolved Nutrient Oxygen Concentration During Dry and Wet Conditions in Storm Drains and Surface Water Sites in Portsmouth, NH 8/99-6/00

	DRY					WET				
Site	Nitrate mg/l	Ammonium mg/l	DIN mg/l	Phosphate mg/l	Diss. O2 mg/l	Nitrate mg/l	Ammonium mg/l	DIN mg/l	Phosphate mg/l	Diss. O2 mg/l
	Stormwater pipes					Stormwater pipes				
8300	-	-	-	-	-	0.259756	4	0.534716	0.0241644	-
8400	0.36±0.21	0.64±0.35	0.90±0.44	0.091±0.111	-	0.67±0.46	1.01±0.70	1.61±0.83	0.161±0.105	-
GBW 18 cp	-	-	-	-	-	0.204918	0.661696	0.866614	0.026333	-
	Surface water					Surface water				
GBW 18	0.26±0.17	0.17±0.18	0.42±0.25	0.020±0.011	10.5±1.6	0.35±0.26	0.12±0.10	0.50±0.14	0.025±0.026	9.9±1.1
GBW 19	0.49±0.22	0.12±0.10	0.61±0.30	0.015±0.011	11.6±2.4	0.43±0.15	0.21±0.19	0.61±0.29	0.021±0.013	10.3±2.4
8100	0.64±0.21	0.12±0.08	0.77±0.27	0.008±0.004	12.4±2.1	0.238	0.133014	0.371014	0.012±0.006	11.6±2.0

Source: Jones, S.H. 2000. *Strategy for Identifying Priority to Urban Contamination Sources to Coastal Waters*. Final Report to the New Hampshire Coastal Program Office of State Planning. Concord, New Hampshire.

Table 10 Average Dissolved Nutrient and Oxygen Concentrations in Storm Drains and Surface Waters in Portsmouth, NH 8/99-6/00

Site #	Nitrate mg/l	Ammonium mg/l	DIN mg/l	Phosphate mg/l	N:P	Dissolved O_2 mg/l	oxygen % saturation
			Storm Drains				
8300	0.259756	0.27496	0.534716	0.0241644	22.12825479	-	-
8400	0.45±0.32	0.78±0.52	1.04±0.69	0.115±0.110	9.043478261	7.2	71.2
GBW18cp	0.204918	0.661696	0.866614	0.026333	32.90980898	-	-
			Surface waters				
GBW 18	0.27±0.17	0.16±0.17	0.44±0.23	0.021±0.014	20.95238095	10.5±1.6	96.7±8.5
GBW 19	0.48±0.20	0.15±0.13	0.61±0.29	0.017±0.011	35.88235294	11.6±2.4	92.4±10.1
8100	0.59±0.24	0.12±0.08	0.77±0.27	0.009±0.005	85.55555556	12.4±2.1	95.8±10.2

Source: Jones, S.H. 2000. *Strategy for Identifying Priority to Urban Contamination Sources to Coastal Waters*. Final Report to the New Hampshire Coastal Program Office of State Planning. Concord, New Hampshire.

2.5.2 Sources and Impacts of Nutrients

Nutrient enrichment in surface waters is typically caused by excess nutrient inputs from anthropogenic sources, such as fertilizers, WWTF effluent, septic systems and other sewage sources, stormwater runoff and atmospheric deposition. Excess nutrients can lead to increased biomass and incidence of phytoplankton blooms, increased biomass and areal cover of nuisance plant species, and indirectly to decreases in dissolved oxygen (DO) in the water column. Elevated nutrient conditions can cause replacement of indigenous species by nuisance and invasive plant species that are more suited to such conditions. An increase in plant cover on sediments can cause problems for the survival of other benthic organisms. Increases in phytoplankton biomass can exceed sustainable levels and the resulting die off causes a build up in organic matter. Depressed levels of DO in surface waters results from excessive oxygen demand by respiring algae and heterotrophic bacteria, in addition to oxygen uptake by fish and benthic animals, which exceeds the inputs of oxygen from photosynthesis processes and diffusion from the atmosphere. Increases in plant and phytoplankton biomass can cause build up of organic matter that is broken down by oxygen-consuming bacteria. Bacteria can also depress oxygen levels in the water column when they use oxygen to oxidize inorganic energy sources such as ammonium.

2.6 Sedimentation and Erosion

2.6.1 Status and Trends of Sediments

Information and data about sedimentation and erosion in the Hodgson Brook watershed are only available for sites in the Pease International Tradeport. The elevated levels of suspended sediments within Hodgson Brook are suspected to be from erosion of exposed soils, discharges from storm drains and movement from disturbed sites, such as those under development. The Hodgson Brook watershed faces ongoing land use changes; in particular development that is occurring at a rapid pace at the Pease International Tradeport since the Air Force base closure in 1991. New businesses have taken over existing infrastructures and many have built new buildings. Regulatory programs have been instituted to protect surface waters from erosion and manage stormwater runoff during construction and post development.

DES initiated the Site Specific/Alteration of Terrain program to regulate erosion and manage stormwater runoff from all types of development. Specifically, a permit is required if a proposed project could disturb >100,000 ft^2 of terrain (http://www.des.state.nh.us/sitespecific). The program intends to protect surface waters by managing stormwater runoff from areas under construction and developed sites. If a violation of permit is suspected, DES will perform a thorough inspection of the site. In some cases DES will issue a letter of deficiency and require an amended plan for site remediation from the guilty party. DES is also authorized to issue administrative fines and/or refer the case to the state Department of Justice. Even with regulatory programs in place there have been recent violations of Site Specific permits in the Hodgson Brook watershed. The DES has also noted impaired surface water quality due to sedimentation in the Brook.

2.6.2 Sources and Impacts of Sediments and Erosion

Excessive sedimentation and associated pollutants can have an impact on surface water quality. They can be washed from disturbed sites during rain events and enter a nearby waterway. Most often construction sites have the greatest ability to cause disturbances. Removal of vegetation, soil, and natural drainage areas can alter the natural flow of surface waters disturbing soils and making them mobile.

Winter road treatment is also a large source of excessive sedimentation especially during spring runoff. Using sand as a deicing material is a common practice in New Hampshire. Removal of the sand in the spring is not always a common practice and results in sedimentation of waterways.

Sediments can act as a vector for microbes and as a reservoir for pollution. Sediments are the product of erosion and runoff from land surrounding surface waters. They are an important and ubiquitous contaminant in stormwater runoff, and can impair natural aquatic functions, by smothering benthic aquatic insects, decreasing survival of fish eggs, destroying fish spawning areas, decreasing DO and reducing the channel capacity or flow (CWP, 2003a). Sediments can cause turbidity and light limitations in the water column.

The DES Site Specific/Alteration of Terrain program regulates erosion and manages stormwater runoff from all types of development that meet permit requirements. There have been two recent violations of Site Specific permits in the Hodgson Brook watershed. The first occurred on March 12, 2001 at 164/166 Corporate Drive, Flextronics International, situated at the Pease International Tradeport. On March 15, 2001 a letter of deficiency was sent to the Kane Company Inc., sub lessee of the property at the Pease International Tradeport. The letter outlined site disturbance violations. Specifically, the site disturbance exceeded permit lines as shown on plans approved under the Site Specific permit and the site did not have appropriate temporary erosion control measures in place. The Kane Company did not correct all violations and was summoned to a formal hearing and fined $6,000.

The second violation occurred on April 1, 2003 at Liberty Mutual Insurance located on 207 International Drive, at the Pease International Tradeport. The sub lessee of this project is the same as the previous violation by the Kane Company Inc. An onsite inspection found a deficiency in which temporary erosion control measures were not in place, and both a wetland and a perennial stream disturbance violation had occurred. A letter of deficiency was issued on March 31, 2003. On April 21, 2003 the contractor sent a response to the letter of deficiency in which they addressed corrections to the violations and deficiencies. Once a final inspection is completed in August 2003 the matter will be closed if all deficiencies have been addressed.

Another instance of a sedimentation problem and remediation in the Hodgson Brook watershed was in 1997 when the PDA and DES sponsored the Grafton Ditch Restoration Project. According to the DES, water quality had been impaired due to sedimentation in the ditch and polluted runoff from paved areas within the Grafton Ditch drainage area. During the Grafton Ditch Restoration Project, water samples were analyzed for metals and pesticides (Pease Development Authority, 1997), however, there has been no formal report published about the success of this project or the monitoring results.

One of the greatest potential problems of contaminated sediments within the Hodgson Brook watershed is the impact the contaminants may have on living organism through direct contact or indirectly by passing through the food web. Although there have been no studies conducted on the impacts of sedimentation on aquatic organisms in Hodgson Brook, but other studies have shown increased sediments can change invertebrate communities and, if sediments are contaminated, toxic chemicals can increase in concentration through the food chain to potentially harmful concentrations in larger aquatic organisms. These impacts can persist when sedimentation problems remain unresolved.

2.7 Solid Waste

All waterways and wetlands within the state are protected from illegal dumping and filling. DES is authorized to enforce, RSA 149-M:15, a statute which prohibits illegal disposal of solid waste. Any persons violating this can be required to cleanup the waste and may face up to one year in jail and a $25,000 penalty (http://www.des.state.nh.us). The City of Portsmouth also has regulations against solid waste. Chapter 3, Article II, Section 3.204 prohibits "the disposal of any materials on public or private property in any manner not permitted by this ordinance or by state law." Portsmouth Public Works Department has the authorization to site violations and fine guilty parties.

Occasionally, DES enforces RSA 482 for violations that include such illegal activities as dumping leaf and yard waste on the bank or in a stream. The statute, RSA 482-A:3 Excavating and Dredging Permit reads "no person shall excavate, remove, fill, dredge or construct any structures in or on any bank, flat, marsh, or swamp in and adjacent to any waters of the state without a permit from the department." (http://www.gencourt.state.nh.us/rsa/html/L/482-A-3.htm).

2.7.1 Status and Trends of Solid Waste

Even though there has been not been any documentation of illegal dumping activities in the Hodgson Brook, there is enough trash along its banks, which are cleaned annually by a local advocates group, that suggests littering and dumping are significant problems in the watershed. This section discusses the evidence and findings of the Advocates for the North Mill Pond annual cleanup along the banks of the Hodgson Brook watershed.

Several highways and roadways crisscross the watershed. The NHDOT Bureau of Turnpikes maintains most of the lane miles in the Hodgson Brook watershed. Roadside maintenance, mowing and trash removal are performed annually. There is no record kept for the number of trash bags generated during the annual cleanup, and currently the Adopt a Highway program does not sponsor any highway miles in the Hodgson Brook watershed.

Pond is the presence of accumulated rubbish and industrial waste along the shores and mudflats of the pond (ANMP, 1998). Each year the Advocates for the North Mill Pond conduct a shoreline cleanup, for areas that require attention. The effectiveness of the cleanup depends on the number of people involved, and the Advocates send out press releases to local papers to announce the cleanup. This approach also promotes stewardship among the residents of Portsmouth.

There have been eight cleanups to date. After each cleanup the Advocates write a summary of what they found for the local newspaper. In 1997, five tons of garbage including one ton of discarded tires were gathered. In 2001, the volunteers filled an 8-cubic yard dumpster. In 2002 volunteers removed sleeping bags, kitchen stoves and filled an industrial sized rubbish container. The Advocates believed that the 2002 cleanup had more trash removed than in previous years, suggesting more dumping is occurring on the banks of North Mill Pond.

Even with the efforts of the NHDOT and volunteers in the annual cleanups it is evident that illegal dumping along the banks of the Hodgson Brook watershed is still an issue. In addition to discarded appliances and tires, dumping leaf and yard waste on the bank of Hodgson Brook appears to be a common practice. Recognizing this Konisky (2000, 2001) worked on restoration projects in North Mill Pond, one of which included the removal of debris from the eastern subtidal portion of the pond. There is much debris in this area that is not only an eyesore, but potentially harmful to NMP habitats. A scuba team removed two truck loads of submerged debris (tires and metals) from the large subtidal pool at the northeast section of the pond. In the channel at the Maplewood Avenue Bridge, the team also moved large rocks that were infringing on the natural tidal exchange. Even with yearly removal of debris, and coverage of these activities in newsletters and the local newspaper, there is still a problem of dumping.

2.7.2 Sources and Impacts of Solid Waste

Littering and illegal dumping are the leading causes of the solid waste problem in the Hodgson Brook watershed. Anecdotal accounts of automobile drivers emptying the contents of their ashtrays and people dumping lawn wastes have been observed. Not only does solid waste diminish the aesthetic value of the watershed, but it can degrade the natural habitat of animals, plants and other aquatic organisms.

2.8 Other Sources of Contamination

Deicing materials applied to the roadways during winter months are another source of contamination to nearby surface waters. Although the frequency and amount of these materials is not measured, it is known that 32% of the watershed is comprised of impervious surfaces. Other studies have proved deicing materials can have a negative impact on nearby waterways.

Along with general maintenance of roads, the NHDOT is also responsible for clearing and salting some of the roadways in the Hodgson Brook watershed during the winter months. Sodium chloride (NaCl) is the primary substance used by the NHDOT to treat roads covered with snow and ice. Individual patrol stations are responsible for clearing roads in their district and monitoring salt application rates. The amounts of NaCl vary depending on the number of lanes and flow of traffic a road receives, based on annual estimates. All amounts of NaCl and sand applications are reported on a weekly basis throughout the duration of winter. These figures represent the overall applications over general areas that are not directly related to watershed boundaries. Thus, the amounts of road treatments used in the watershed are not available for assessing their environmental impacts.

Both NaCl and sand mixtures could be potential sources of impact. NaCl can cause increased salinity in soils and water, and sand can cause sedimentation of waterways. Hodgson Brook flows along the Spaulding Turnpike, Interstate 95, the Portsmouth Traffic Circle, the Rt.1 Bypass, Rt. 1 and many city streets, all of which receive regular applications of road salt during the winter. The impervious surface in the watershed includes a number of parking lots which also receive doses of salt/sand mixtures to aid in snow removal.

Trucking accidents and associated spills also pose a hazardous threat to roadside vegetation and waterways, especially if large volumes of toxic organic chemicals like oil and gasoline were to spill onto the roadway and wash into storm drains or culverts. DES has a spill response team available 24 hours a day to respond to and cleanup the early stages of a spill (http://www.des.state.nh.us/orcb/irs_intro.htm).

Chapter 3 Watershed Development: Anthropogenic Impacts

3.1 Land Use and Development Issues and Trends

This section describes the past and present land uses, along with the issues associated with a growing population and rapid development. The closure of the Pease Air Force Base in 1991, led to dramatic changes for the Hodgson Brook watershed and the City of Portsmouth. "High tech" industries and the workers associated with these new companies have since moved to the Pease International Tradeport and the Seacoast and had a lasting impact on the City of Portsmouth.

3.1.1 Pease International Tradeport

Pease International Tradeport houses more than 100 high tech companies that do everything from web design and hosting to software development to manufacturing computers and other hardware (http://www.seacoastnewspapers.com/2000news/12_31biz.htm). In 2000, the jobs being generated at Pease were luring many people to the Seacoast, creating the worst housing crunch in New Hampshire in twenty-five years, according to Russ Thibeault of Applied Economic Research. He said that the impact of providing municipal services to so many new residents is a dangerous financial liability to the towns surrounding the Tradeport, as are traffic and environmental problems, which typically arise from too much commercial and residential development (http://www.seacoastnewspapers.com/2000news/12_31biz.htm).

Current environmental concerns for the Pease International Tradeport include, but are not limited to, runoff from sites under construction and post construction runoff, stormwater runoff, road maintenance, and de-icing agents on the roads and runways. The threats of these pollutant sources are lessened through permits, programs, and monitoring. For example, the DES Site Specific/Alteration of Terrain program protects surface water quality from land disturbance impacts. The program regulates erosion control on projects under construction and stormwater impacts from projects once completed (Varney, 1996). Permits are required when construction of a contiguous area of 50,000 square feet or more is disturbed if within the protected shoreland or 100,000 square feet or more in all other areas (DES Fact sheet WD-WQE-3). The permits require onsite erosion control on projects under construction and regulate the rate of discharge of stormwater from the projects when completed (Varney, 1996). The DES reviews best management practices (BMPs) for erosion and sediment control, ensuring stabilization of soil and the treatment for stormwater.

3.1.2. Portsmouth

The City of Portsmouth is thriving with high tech related businesses and was named by the Greater Portsmouth Chamber of Commerce as the "e-Coast". Increased business in the area has brought an increased demand for housing and an increased concern over the rising cost of housing in the area. Since 1980 housing prices have increased 173% in the City of Portsmouth. From 1995-2000 the housing price in Portsmouth increased

39.5%, of which 12.5% occurred in 1999 alone (http://www.seacoastnewspaper.com/2000news/12_31biz.htm).

National censuses were conducted in 1990 and 2000. The City of Portsmouth's Planning Board keeps these statistics on file to determine changes or growth over time. The City's Master Plan describes what the city is today, using census, taxing, and zoning information and what the city hopes to be in the future (http://www.cityofportsmouth.com/masterplan). Using the census data, the population changes of the Hodgson Brook watershed can be determined. The only difference between the census years is that in the 1990 survey a different block zone was used for Pease when it was an operating U.S. Air Force Base (AFB) than in 2000 when the base was converted to the Pease International Tradeport. The discrepancies in the survey maps were not a major problem for comparing surveys since the street names had not changed.

The City of Portsmouth Building Inspectors Office keeps a record of the number and types of permits issued every year in Portsmouth. Over the past three years most of the permits have been for the construction of new businesses and the repairs/remodeling of existing homes (Figure 6). In 1990, the portion of the watershed outside the Tradeport had 461 households and 1,267 residents (http://factfinder.census.gov). In comparison the 2000 census depicted growth in the watershed outside the Tradeport. It claimed 1,540 persons residing there in 608 households (http://factfinder.census.gov). There are no longer households in the Pease Tradeport, but industrial growth within the Tradeport and in Portsmouth has increased the number of people desiring to live in Portsmouth. The census figures depict a growth in households and occupants in the Hodgson Brook watershed.

In 2002 the City of Portsmouth Building Inspector Office issued 756 permits, of which 212 were for new construction and 544 for repairs/remodeling (Figure 4). The 212 new construction permits are broken down into business, industrial and residential construction. In 2002 there were 145 permits for new construction of business, 11 industrial, and 56 residential. In 2002 the largest portion of repairs/remodeling permits, 382, was for residential areas (Figure 4). The fraction of these permits in the Hodgson Brook watershed was not determined.

In 2001, 693 total permits were issued. There were 195 permits for new construction and 498 permits for repairs/remodeling (Figure 5). The business category had 138 permits for new construction and 140 for repairs/remodeling. The residential category had 49 for new construction and 349 for repairs/remodeling. In 2000, 737 total permits were issued. Of this total 255 permits were for new construction and 482 for repairs/remodeling, the largest portion of which were for residential repairs/remodeling, 335, and new businesses, 191 (Figure 7).

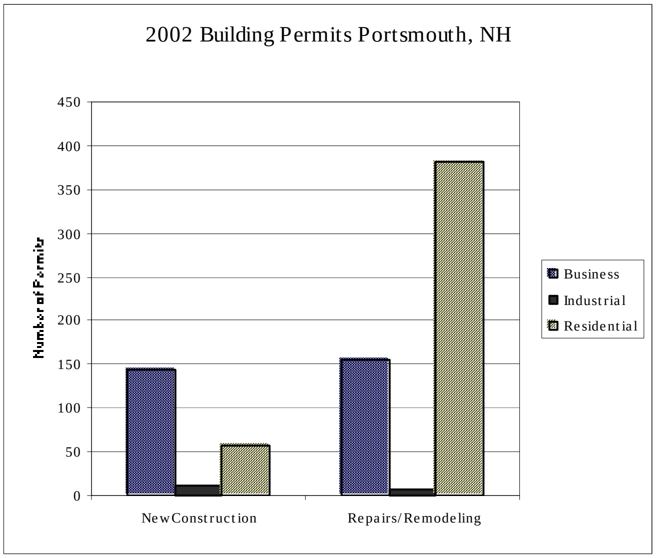


Figure 4 Distribution of Issued 2002 Building Permits in Portsmouth, NH

Source: City of Portsmouth Building Inspector Office. 2003. Portsmouth, NH.

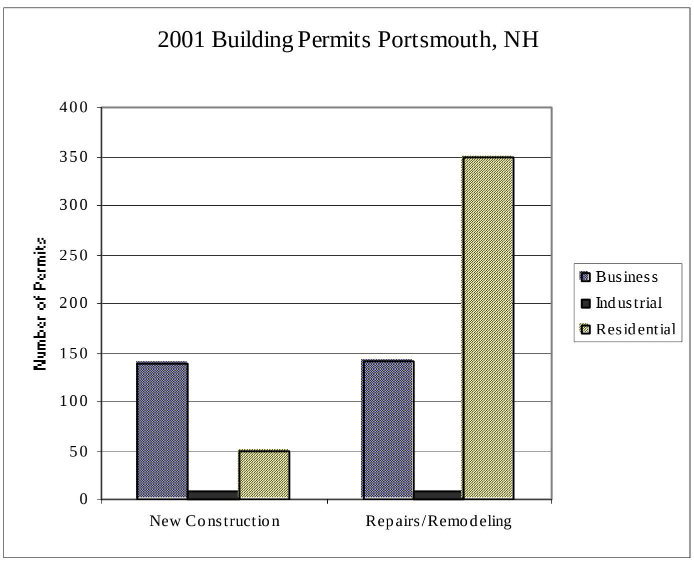


Figure 5 Distribution pf Issued 2001 Building Permits Portsmouth, NH

Source: City of Portsmouth Building Inspector Office. 2003. Portsmouth, NH.

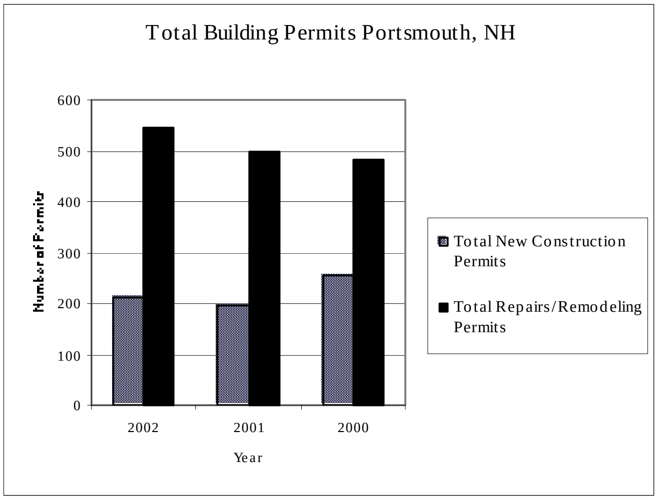


Figure 66 Distributions of Total Building Permits in Portsmouth, NH, 2000-2002

Source: City of Portsmouth Building Inspector Office. 2003. Portsmouth, NH.

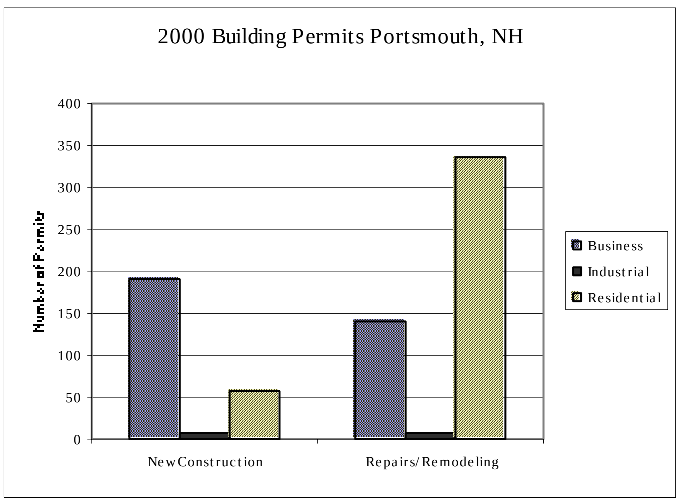


Figure 7 Distribution of Issued 2000 Building Permits in Portsmouth, NH

Source: City of Portsmouth Building Inspector Office. 2003. Portsmouth, NH.

According to the National Association of Homebuilders, in 2000 the median house price in Portsmouth was $185,000.

3.1.3 NHDOT Ten Year Plan

Extensive roadways and highways connect the industry and development that comprises the watershed (Appendix 2). Recently, the NHDOT proposed a program for statewide transportation improvements, also known as the Ten Year Transportation Plan. The plan proposes efforts to improve existing infrastructures, air quality, highway beautification and transit assistance (NHDOT, 2002). This living document has new projects submitted to the NHDOT every two years. All projects are pre-approved to meet environmental standards. There are three projects listed in the Ten Year Plan that are of importance to the Hodgson Brook watershed. One is the replacement of the bridge over the B&M railroad on Route 33. This project is targeted to begin in 2003. The second is the reconstruction of the Route 1 Bypass from the Traffic Circle north to Sarah Long Bridge in 2006. The final is the reconstruction of the section of the Route 1-Bypass from Sagamore Creek to the Traffic Circle including the repairs and construction of five bridges, one of which spans part of the Hodgson Brook watershed. This project is also scheduled to begin in 2006. The NHDOT claims that most of the bridges in the Portsmouth area are in poor condition and need repair. The Ten Year Plan will address the concerns of the NHDOT so the infrastructures remain safe for car traffic.

On March 2, 2003 the Portsmouth Herald reported that these road improvements along Woodbury Avenue, the Portsmouth Traffic Circle and the Rt. 1 Bypass were in the planning stage. DeConto (2003) reported that the Berger Group, an engineering firm from Manchester, hired to assess the location for the new Children's Museum, spurred the improvements. The City's Planning Board recently recommended a capital improvement plan for 2004-2009, which would call for $20 million in spending on main roads running through the Christian Shore neighborhood that includes Woodbury Avenue.

Alex Vogt and Charles Hood, project managers of the NHDOT, have been assigned to review the environmental impacts (NEPA) and assessments for the projects listed above. They will report on the natural, cultural and socio-economic resources within the project area. Environmental investigations and preliminary designs will begin in spring 2003.

3.2 Growth and Development Impacts to Hodgson Brook

The National Census trends show continued population growth in the Portsmouth area and an increase in the amount of people living within the Hodgson Brook watershed boundary. Portsmouth's attractive characteristics, such as historic, cultural and art festivals; a working port; and an expanding Tradeport, draw more people and development to the watershed.

Along with the people and development, hard or impervious surfaces are created to accommodate their needs. New buildings add new rooftops and parking lots along with access roads, and sidewalks, all of which will increase the impervious surface cover. Impervious coverage explains, and sometimes predicts, how severely the environmental quality indicators change in response to different levels of watershed development (CWP, 2003a). The Center for Watershed Protection (2003b) found that an increased amount of development in an urbanized area and associated impervious cover can further impair and degrade surface water. How these impervious surfaces are used is an entirely different story. Usually increased impervious surfaces can increase the amount of nonpoint source pollution and stromwater flows. However, if impervious surfaces are designed in a manner which redirects runoff and or buffer regions are developed around the impervious surfaces to reduce the stress put on aquatic systems, then impervious surface can be less of a potential problem for environmental managers.

The impact of impervious surfaces can have a negative influence on surface water quality in urbanized areas. CWP (2003a) states that if impervious surface covers ≥10% of a watershed it will decrease water quality in surface waters, and severe degradation is predicted beyond 25% impervious coverage. The Hodgson Brook watershed has an estimated 32% impervious coverage.

CWP (2003a) concluded that streams with >25% impervious coverage in their watershed cannot support their designated uses since they are severely degraded from a physical and biological standpoint. CWP (2003 a) suggest the need for a more accurate calculation of impervious surface within the buffer region of a stream. The total impervious cover from an entire watershed may not be representative of the immediate development within the buffer region of the stream. Since large amounts of impervious surface within the buffer region can have a negative impact on water quality in the stream, calculating the amount of impervious surfaces in the buffer region will provide insight to health of the stream (CWP, 2003a).

The US Geologic Survey (USGS) is currently studying the relationship between impervious surfaces, macroinvertebrates, buffer zones, and watershed characteristics (Jeff Deacon, personal communication). One of the sampling locations for this project is located on Hodgson Brook at the Cate Street Bridge. In addition to the parameters mentioned above, water samples are analyzed for nitrogen, phosphorus, *E. coli*, and other basic field parameters. A report is expected in 2004.

The City of Portsmouth's Master Plan addresses concerns for aging infrastructures and potential expected growth for 2002 to 2004. The plan lists proposed Citywide Projects to meet the demands of a growing area. Of the 2003 projects listed, four were planned for the Hodgson Brook watershed. They include the Dennett Street Paving Project; the Brackett Road water, sewage and drainage; the I-95 Pannaway Manor noise/safety improvement; and water and sewage upgrade on Corporate Drive. At least two of these projects are underway (Dennett Street and Corporate Drive). Future projects, such as the road maintenance and bridge construction by the NHDOT and City's storm drain mapping project will improve the infrastructure and long-term maintenance of these costly necessities of the City.

The City is in the process of developing a new Master Plan. An intensive community-involvement phase called "Portsmouth Listens" was recently completed. This initial phase in master development allowed for citizen input on the areas of most concern to people who live and work in Portsmouth. The citizen input and ideas included redevelopment of downtown buildings for mixed use, increase in the use of public transportation and continued clean up and access to the City's natural resources.

Protection measures have been implemented to slow down the negative impacts of development on the Hodgson Brook watershed. The DES and the City of Portsmouth use regulatory criteria to protect surface waters, sediments, and all living organisms from degradation or endangerment. In the Hodgson Brook watershed several regulatory programs are in effect. Some of them include the EPA Clean Water Act, DES Site Specific Program, DES Solid Waste Recycling, NPDES Phase I and II Stormwater Regulations, EPA Clean Power Act, EPA Hazardous Substance Criteria, and the DES Shellfish Program. Through the City of Portsmouth's Wetland Inventory, two potentially prime wetlands were identified in the watershed. Should the DES support these findings, these two areas will have stricter development and permit guidelines. These programs are used to prevent further impairment and, in some cases, reverse historical damage. Management strategies for the Hodgson Brook watershed should include restoration and protection actions. Based on the findings of this report, the strategies should include a minimization or elimination of impacts to water quality by human uses.

Chapter 4 Summary and Conclusions

This report provides an assessment of existing environmental data and information for Hodgson Brook and its receiving water, North Mill Pond. Challenges for this watershed are great. Previous and historic land uses have resulted in degraded water and sediment quality. Impervious coverage is at a high of 32% and development continues at the Pease International Tradeport. While significant progress has been made in remediating impacts of the former Pease Air Force Base, polluted stormwater runoff remains one of the biggest identifiable threats to water quality. In order to meet the challenges posed by growth in population, industry and development, there needs to be an effective restoration plan instituted for the Hodgson Brook watershed. The Advocates for the North Mill Pond, with support from the community, DES and EPA, are developing such a plan. The Hodgson Brook Restoration Plan should be completed by the summer of 2004.

4.1 Geographic and Physical Setting Summary

The Hodgson Brook watershed is situated mostly in Portsmouth, New Hampshire, but also crosses into the Town of Newington in the extreme upper northwest corner of the watershed. The highly urbanized watershed is dominated by the Pease International Tradeport, formerly a US Air Force Base. The Tradeport is now occupied by airport industry and commercial industry and business corporations. The remainder of the watershed is comprised of turnpikes, residential neighborhoods and commercial sectors. A large portion of the watershed, 32%, is covered by impervious surfaces.

The natural course of the brook has been altered to meet the growth and development needs of the watershed. Hodgson Brook flows through the Pease Tradeport, where its headwaters lie, before flowing past through several highways, businesses and neighborhoods, and finally flowing into North Mill Pond. The historic and present land uses of the watershed have negatively influenced the environmental quality of the brook. It is a concern that the brook is a significant source of pollution to the tidal receiving waters of the Pond.

4.2 Environmental Quality Summary

A summary of the Hodgson Brook environmental quality is provided in Appendix 16. The following summaries expand on the table provided in the Appendix 16.

4.2.1 Fecal Borne Microbial Contaminants Summary

Information about microbial contamination in the Hodgson Brook watershed is only available for the mouth of Hodgson Brook and North Mill Pond. Researchers have reported the mouth of Hodgson Brook and its receiving water, North Mill Pond. Researchers have reported the mouth of Hodgson Brook and North Mill Pond as having varied and ubiquitous fecal borne indicator bacteria.

Only a few studies of microbial pollution have been conducted in Hodgson Brook/North Mill Pond area. The Great Bay Coast Watch (GBCW) reported that the annual geometric mean fecal coliform concentration at Bartlett Street site (GB 19) in North Mill Pond was the highest of any site monitored by the GBCW network in 1997, 1999, 2000, and 2001. Although GB 19 had the highest annual geometric mean fecal coliform, the geometric mean fecal concentrations at GB 19 have been decreasing each year (Reid 1998, 2001, 2002, 2003).

Jones (2000a) reported that the average instantaneous flow rates showed wet weather flow to be significantly greater than dry weather flow at GBW 18 and GBW 19, suggesting that loading of bacterial contaminants during wet weather can contribute significant levels of bacterial pollution. The bacterial contaminant loading at GBW 19 was the highest of three study sites for which loading estimation was possible, and was considered a high priority site for follow-up studies. ANMP (1998) sampled for *E. coli* and enterococci at Maplewood Avenue (GB 18) and Bartlett Street (GB 19). They found the instantaneous loading of *E. coli* increased during a storm event from 1.17×10^{5} cfu/s to 4.26×10^{7} cfu/s, an increase of greater than 36 times. Other evidence exists that storm-related bacterial pollution is a significant concern to Hodgson Brook, at least near its mouth (Jones, 2000a).

In 1998, the Gulfwatch program results confirmed that mussels from a site in North Mill Pond (NHNM) may have been exposed to relatively recent pollution associated with fecal contamination (Jones and Landry, 2000).

In addition, DES has conducted extensive investigations of municipal storm drains and grey water sources throughout Portsmouth and has found persistent illicit connections along the Dennett Street drainage area. The City of Portsmouth investigations revealed that sewer systems are exfiltrating into storm drain systems. The City is currently fixing the problem. Under NPDES *Phase II Stormwater Regulations* the City will inventory all stormwater conveyances such as pipes and culverts.

4.2.2 Toxic Organic Chemicals and Metal Pollutants Summary

Information and data on toxic contaminants are only available for the Pease International Tradeport portion of the watershed and the North Mill Pond.

Blue mussels, *Mytilus edulis*, were sampled by the Gulfwatch program to assess biological exposure to toxic chemicals in the coastal waters of New Hampshire (Jones and Landry, 2000). The spatial distribution of toxic chemicals in New Hampshire mussels showed North Mill Pond to have the highest concentrations of all three classes of organic chemicals in New Hampshire. Also in North Mill Pond, the ANMP (1998) found that mercury (Hg) exceeded the NOAA Effects Range Medium (ER-M) criteria (0.71 mg/g DW) at a site located near the Hodgson Brook inlet to the pond.

In the Pease Tradeport the PDA collects monthly surface water samples in Grafton Ditch for BOD, surfactants, oil/grease, iron, zinc, lead, nickel and cyanide. Since sampling began there has been one exceedance of State criteria in November 2001 for surfactants. The USAF monitors both Grafton and Newfields Ditches annually per the Long Term Monitoring Plan. Grafton Ditch sediments and surface waters are monitored. 2001 sampling results showed a decreasing PAH trend in Grafton Ditch and a continued exceedance of arsenic. Pesticides, mainly DDT and metabolites (4,4-DDD) were the most frequently detected pesticide compounds in Grafton Ditch during 2000. Newfields Ditch is monitored for groundwater only. Sampling these sites will continue on an annual basis.

Public health risks associated with toxic substances in seafood that may be harvested in coastal New Hampshire include mercury and PCB contamination in bluefish, lobster tomalley and shellfish. In 1991 a study conducted by the US Food and Drug Administration and DHHS determined that lobster tissue in lobsters from Great Bay Estuary was contaminated with PCBs (DES, 2000). There is concern that the same atmospheric and land uses that influence the pollutants in New Hampshire estuaries and coastal waters could also negatively impact organisms in the Hodgson Brook watershed.

4.2.3 Historical and Present Air Force Base Related Contaminants Summary

The Department of Defense Installation Restoration Program identified potential human and ecological health contaminants on the Pease International Tradeport. Neither of the ditches was found to have human health risks associated with them, although ecological risks were found for both ditches. Contaminants were located and contaminated soils were removed near Grafton Ditch. A Long Term Monitoring Plan includes annual monitoring of Lower Grafton Ditch and Newfields Ditch. Recent sediment samples in Grafton Ditch indicate arsenic has the highest rate of criteria exceedance of metals sampled. Total PAHs were found to have a decreasing trend when measurements were compared to historical data. Water samples exceeded the following metals: aluminum, cadmium, iron, and lead. Toluene was the only VOC detected in 2001 sampling.

In upper Newfields Ditch surface water, inorganic analytes were detected above DES standards. These included aluminum, beryllium, cadmium, copper, iron, lead, mercury, and zinc. In sediments, organic compounds (VOCs, SVOCs, and pesticides), inorganic compounds and metals were detected above NOAA ER-L sediment concentrations. In lower Newfields Ditch, surface water and sediments were also collected. In surface water, pesticides, DDT and heptachlor epoxide, exceeded DES criteria. Inorganic chemicals in surface waters were also found to exceed DES criteria. In sediments S-VOCs (including PAH) and other organic compounds were detected in 2001.

The Agency for Toxic Substances and Disease Registry (ATSDR) sampled both Grafton and Newfields ditches for contaminants associated with public health hazards. According to the EPA Hazardous Substance criteria, all contaminants were found to be below levels of concern for health risk. Since no exposure is occurring, ATSDR declared Grafton and Newfields ditches not to be a public health hazard.

4.2.4 Nutrients Summary

Information about nutrient loading in the Hodgson Brook watershed is only available for the mouth of Hodgson Brook and the North Mill Pond. Data are needed for the upper portion of the watershed. Ammonium, nitrate and dissolved inorganic nitrogen (DIN) concentrations were found to decrease from sites along a transect that started at a Hodgson Brook site upstream of Bartlett Street and continued out to the Piscataqua River (Jones, 2000a). Average loading rates for nitrate, ammonium and phosphate were all 2-3x higher at GBW 19 (Hodgson Brook inlet, Bartlett Street) compared to other sites (Jones, 2000a).

4.2.5 Sedimentation and Erosion Summary

Information and data available about sediment and erosion in the Hodgson Brook watershed are limited and only available for the Pease International Tradeport. The DES has records of two violations in the Hodgson Brook watershed for the Site Specific/Alteration of Terrain permit program, which regulates erosion and manages stormwater runoff during development. Only the first violation has been resolved. The second still needs a final inspection which will be completed by August, 2003. The DES has also noted impaired surface water quality due to sedimentation in the watershed.

One of the greatest potential problems of contaminated sediments within the Hodgson Brook watershed is the impact the contaminants may have on living organism through direct contact or indirectly by passing through the food web.

4.2.6 Solid Wastes Summary

Littering and illegal dumping are the leading causes of solid waste in the Hodgson Brook watershed. The ANMP conduct an annual cleanup of the banks of North Mill Pond. Over the past few years there had been a decreased though still substantial, removal of trash from the area. Even though the City of Portsmouth and DES both protect against illegal dumping and filling, the amount of trash removed from the area is increasing.

4.3 Watershed Development Summary

The City of Portsmouth is experiencing an increase in population and growth in businesses, mostly due to the development of the Pease International Tradeport. The National Census trends show increased population growth in the Portsmouth area and an increase in the amount of people living within the watershed boundary. Portsmouth's attractive characteristics, such as historic, cultural and art festivals; a working port; and an expanding Tradeport, draw more people and development to the watershed.

Current environmental concerns for the increased growth include runoff from sites under construction and post construction runoff, stormwater runoff, road maintenance and an increased amount of impervious surfaces. Changes of land use and impervious surfaces can predict how development, and associated increase in stormwater runoff, will affect surface waters. The Center for Watershed Protection (2003a) states that impervious coverage can explain how severely the environmental quality indicators change in response to different levels of watershed development. They found that an increased amount of development in an urbanized area and associated impervious cover can further impair and degrade surface water. Impervious surface ≥10% of a watershed can decrease water quality of surface waters, with severe degradation expected beyond 25% impervious coverage. The Hodgson Brook watershed has 32% impervious surfaces.

Protection measures have been implemented to slow down the negative impacts of development on the Hodgson Brook watershed. The DES and City of Portsmouth use regulatory programs to protect surface waters, sediments, and all living organisms from degradation or endangerment. These programs are used to prevent further impairment due to human uses.

4.4 Conclusions

The natural integrity of Hodgson Brook watershed is threatened by both historical pollution and the continual development of business and residential areas. Land use changes, in particular the conversion of the former air force base into the Pease International Tradeport, has brought more commercial development and people to the watershed. Monitoring and subsequent remediation have revealed the extent to which natural resources were exploited at the former air force base. The change over to the Tradeport has resulted in increased development and construction of businesses. These businesses are and continue to attract more people to the Seacoast. Monitoring programs at the Tradeport and the mouth of Hodgson Brook have shown storm water runoff, storm drains, and movement of sediment from disturbed sites should be priorities for environmental managers.

Already the watershed is highly urbanized with 32% covered by impervious surfaces, the largest of which is from airport businesses. The Center for Watershed Protection claims that watersheds with greater than 20% impervious surfaces are severely degraded. It is a concern that the amount of impervious surface in the Hodgson Brook watershed and the polluted runoff is having a deleterious effect on the surface waters of Hodgson Brook. Current regulatory programs exist to protect the designated uses of surface waters, wetlands, and natural areas. Both the City and State regulate activities in the land surrounding the Tradeport. The Pease Development Authority and the State regulate activities within the Tradeport. Even though regulatory programs, which often times include the issue of permits, are enforced, violations still occur. Permits, monitoring programs, and volunteer efforts can reduce the negative impacts associated with development. A conscious effort must be made to stop further degradation of Hodgson Brook so that managers may undo the damages of the past while preserving the integrity of the watershed for the future.

Work Cited

Advocates of the North Mill Pond (ANMP). 1998. *The state of the North Mill Pond, Portsmouth, NH*. A report to the NH Estuaries Project, Portsmouth, NH.

Arnold, C.L. and C.J. Gibbons. 1996. *Impervious Coverage: The emergence of a key environmental indicator*. American Planning Assoc. J. 62: 243-258.

Bechtel Environmental Inc. 2000. *Basewide surface water, sediment, and fish tissue monitoring, proposed modification to long term monitoring activities*. Pease Air Force Base. Oak Ridge, TN.

Britz, Peter. City of Portsmouth Environmental Planner. Personal Communication. June 2, 2003.

City of Portsmouth, New Hampshire. <http://www.cityofportsmouth.com/masterplan> February 18, 2003.

CLD Consulting Engineers and GES Grove Environmental Services, Inc. 2003. *City of Portsmouth, NH citywide wetlands inventory*. Portsmouth Planning Department. Portsmouth, NH.

Clean Water Act (CWA). 2000. *High arsenic levels found in soil samples from Kittery and Eliot; local residents and environmentalists point to power plant emissions as likely source, call on State of New Hampshire to release study of soot deposition from local plants*. Portsmouth, New Hampshire.

Center for Watershed Protection (CWP). 2003a. *Impacts of impervious cover on aquatic systems*. <http://www.swp.org>. Maryland.

Center for Watershed Protection (CWP). 2003b. <http://www.cwp.org> June 3, 2003.

Daley, Michael. US EPA. Personal Communication July 14, 2003.

DeConto, Jesse J. 2003. *Traffic mitigation part of children's museum planning*. Portsmouth Herald. Portsmouth, New Hampshire.

DeConto, Jesse J. 2002a. *Fuel in pond traced to vehicle.* March 21, 2002. Portsmouth Herald Portsmouth, NH.

DeConto, Jesse J. 2002b. *Petroleum leak springs near pond*. March 20, 2002. Portsmouth Herald Portsmouth, NH.

Deacon, Jeff. USGS. Personal Communication March 19, 2003.

Dexter, Gerald. Pease Development Authority. Personal Communication March 5, 2003.

Environmental Protection Agency. <http://www.epa.gov>. February 11, 2003.

Environmental Protection Agency (EPA). Unpublished. New Hampshire National Coastal Assessment (NCA). Portsmouth, NH.

Evers, D.C. 2001. *Assessing the potential impacts of methylmercury on the Common Loon in southern New Hampshire*. BioDiversity Research Institute. Falmouth, Me.

Geldreich, E.E. 1996. *Pathogenic agents in freshwater resources*. Hydrological Processes 10: 315-333.

Gutro, Doug. 1997. *New England military base clean ups move forward as EPA approves plan*. 10/22/97 <shttp://www.epa.gov/NE/pr/1997/pr_102297c.html>

Hilton, Scott. DES. Personal Communication July 31, 2003.

Jones, S.H. 2003. *Application of ribotyping for tracking bacterial pollution sources in the Webhannet River (Maine) watershed*. Final site report. CICEET, UNH, Durham, NH.

Jones, S.H. 2002. *Application of ribotyping for tracking bacterial pollution sources in New Hampshire's shellfish water*. Final report. NH Coastal Program, Portsmouth, NH.

Jones, S.H. 2000a. *Strategy for identifying priority to urban contamination sources to coastal waters*. Final Report to the New Hampshire Coastal Program Office of State Planning. Concord, NH.

Jones, S.H. 2000b. *A technical characterization of estuarine and coastal New Hampshire*. Final Report to the New Hampshire Estuaries Project. Portsmouth, New Hampshire.

Jones, S.H. 1999. *Public health significance of stormwater-borne microorganims*. Final Report to the New Hampshire Department of Environmental Services. Portsmouth, New Hampshire.

Jones, S.H. 1998. *Stormwater contamination of New Hampshire coastal surface waters*. Final Report. NH Office of State Planning/Coastal Program, Concord, New Hampshire. 72 pp.

Jones, S.H.; Landry, N. 2003. *Tracking bacterial pollution sources in Hampton Harbor*. Final report. New Hampshire Estuaries Project, Portsmouth, NH.

Jones, S.H. and H. Gaudette. 2001. *Stormwater-related bacterial and trace metal contamination of New Hampshire tidal rivers*. Final Report to the New Hampshire Coastal Program Office of State Planning. Concord, NH.

Jones, S.H. and N. Landry. 2000. *The New Hampshire Gulfwatch Program: 1998*. NH Department of Environmental Services and the Gulf of Maine Council, Concord, New Hampshire.

Jones, S. H., B.W. Summer-Brason. 1999. *Incidence and detection of pathogenic Vibrio sp. In a northern New England estuary, USA*. J. Shellfish Res. 17: 1665-1669.

Jones, S.H., H. Gaudette and B. Mosher. 1999. *Stormwater contamination of New Hampshire tidal rivers*. Final Report. New Hampshire Office of State Planning/Coastal Program, Concord, New Hampshire. 22 pp. plus figures and tables.

Jones, S.H. and R. Langan. 1996a. *Assessment of nonpoint source pollution in tributaries entering Great Bay*. Final Report: NOAA Grant Award # NA47OZ0237. NH Office of State Planning, NH Coastal Program, Concord, New Hampshire.

Jones, S.H. and R. Langan. 1996b. *Assessment of the effectiveness of permanent stormwater control measures*. Final report: NOAA Grant Award # NA47OZ0320. NH Office of State Planning, NH Coastal Program, Concord, New Hampshire.

Konisky, R et al. 2001. *Rebuilding the ecosystem of North Mill Pond*. Final Report to US Environmental Protection Agency New England.

Konisky, R et al. 2000. *Great Bay Coast Watch 1990-1999 a ten year report on the volunteer water quality monitoring of the Great Bay estuarine system*. University of New Hampshire Cooperative Extension/Sea Grant Durham, New Hampshire.

Landry, N. 1999. *Elimination of illicit connections in coastal New Hampshire spurs cooperation and controversy*. A final report to the New Hampshire Estuaries Project, Portsmouth, New Hampshire.

Landry, N. 1997. *An investigation of water quality in New Hampshire estuaries*. A final report to the NH Estuaries Project. NH Estuaries Project, Portsmouth, New Hampshire.

Landry, N. DES. Personal communication February 27, 2003.

Miller, Steve. Portsmouth Conservation Commission. Personal communication July 7, 2003.

MWH Americas, Inc. 2002. *Basewide surface water, sediment, and fish tissue monitoring; Pease Air Force Base, Portsmouth, New Hampshire*. Prepared for Air Force Center for Environmental Excellence Environmental Restoration Division Brooks AFB, Texas. Malvern, PA.

Nash, Chris. DES. Personal Communication February 28, 2003.

Nash, Chris. 2002. DES Shellfish Program. *Pease WWTF call 6/20/02*.

Nash, Chris. 2001. *Sanitary survey report for Little Harbor and Back Channel, New Hampshire*. NH Department of Environmental Services Report Number R-WD-01-15.

New Hampshire Department of Environmental Services. Response for Spills. <ttp://www.des.state.nh.us/orcb/irs_intro.htm> July 2, 2003.

New Hampshire Department of Environmental Services. Clean Power Act. <http://www.des.state.nh.us/ard/CleanPowerAct.htm> March 10, 2003.

New Hampshire Department of Environmental Services. Stormwater Monitoring.
<http://www.des.state.nh.us/stormwater> March 5, 2003.
<http://www.des.state.nh.us/stormwater/docs/phase2/fact2-2.pdf > July 23, 2003.
<http://www.des.state.nh.us/StormWater/nhurb2000.pdf> July 23, 2003.

New Hampshire Department of Environmental Services. Site Specific Program. <http://www.des.state.nh.us/sitespecific> May 5, 2003.

New Hampshire Department of Environmental Services (DES). Unpublished. 2000 Hodgson Brook Biomonitoring Project. Portsmouth, NH.

New Hampshire Department of Environmental Services (DES). 2000. *State of New Hampshire 2000 Section 305(b) Water Quality Report*. Concord, NH.

New Hampshire Department of Environmental Services (NH DES). 2000. *An assessment of airborne particulate matter concentrations and deposition in Eliot, Maine*. NH Department of Environmental Services, Concord, NH.

New Hampshire Department of Transportation. 2002. *State of New Hampshire ten year transportation improvement program 2003-2012*. Approved by the Legislature and Signed into Law by the Governor on May 17, 2002.

NOAA, 1999. *Sediment quality guidelines developed for national status and trends program*. NOAA, National Ocean Service, Silver Springs, MD.

O'Shea, M.L. and R. Field. 1992. *Detection and disinfection of pathogens in storm generated flows*. Can. J. Microbiol. 38: 267-276.

Pease Development Authority. *Water quality monitoring plan Grafton Ditch restoration project Pease International Tradeport Portsmouth, NH*. 1997

Pease Development Authority. 1992. Lease for Base Closure Property (Long term basis) on Pease Air Force Base, New Hampshire. April 1992. Lease #USAF-PEA-1-92-032.

Pease Development Authority. <http://www.pease.org> February 12, 2003.

Pitlik, S., S.A. Berger and D. Humminer. 1987. *Nonenteric infections acquired through contact with water*. Rev. Infect. Dis. 9: 54-63.

Pontine Movement Theatre. 2000. *Production of the Dearly Earned, 1994*. 135 McDonough Street Portsmouth, NH.

Reid, A., B.S. Meeker, C. Cugini, K. Cullen, C. Dolan, J. Fox and C. Swasey. 2003. *Great Bay Watch annual report: 2002*. Univ. of New Hampshire Sea Grant Program, Durham, NH.

Reid, A., B.S. Meeker, C. Cugini, K. Cullen, C. Dolan, J. Fox and C. Swasey. 2002. *Great Bay Watch annual report: 2001*. Univ. of New Hampshire Sea Grant Program, Durham, NH.

Reid, A., B.S. Meeker, C. Cugini, K. Cullen, C. Dolan, J. Fox and C. Swasey. 2001. *Great Bay Watch annual report: 2000*. Univ. of New Hampshire Sea Grant Program, Durham, NH.

Reid, A., B.S. Meeker, C. Cugini, K. Cullen, C. Dolan, J. Fox and C. Swasey. 2000. *Great Bay Watch annual report: 1999*. UNHMP-AR-SG-00-2. Univ. of New Hampshire Sea Grant Program, Durham, NH.

Reid, A., B.S. Meeker, S. Burt and M. Anderson. 1998. *Great Bay Watch annual report: 1997.UNHMP*-AR-SG-98_3.Univ.of New Hampshire Sea Grant Program, Durham, NH.

Rice, Peter. Portsmouth City Hall Storm Drain Mapping Project. Personal Communication September 26, 2002.

Rice, Peter. 2002. *Letter to DES in regard to Pease WWTP discharge Portsmouth, New Hampshire (10/23/02)*. City of Portsmouth Public Works Department.

Seacoast Online. <http://www.seacoastnewspapers.com/2000news/12_31biz.htm> May 23, 2003.

State of New Hampshire Legislation. <http://www.gencourt.state.nh.us/rsa/html/L/482-A-3.htm> 3 March 2003.

U.S. Census Bureau. <http://factfinder.census.gov> January 22, 2003.

U.S. Department of Health and Human Services. 1999. *Public health assessment for Pease Air Force Base Portsmouth, Rockingham, New Hampshire*. CERCLIS No. NH7570024847

Varney, R.W. 1996. *Guidelines for the preparation of site specific applications*. Prepared by the NH Department of Environmental Services Water Division. Concord, NH.

Vogel, L. 1995. *Wintering waterfowl on Great Bay.* Great Bay National Estuarine Research Reserve Technical Report No. 2. Great Bay National Estuarine Research Reserve, Durham, NH.

Wallace, Austin. Portsmouth Animal Control Officer. Personal Communication February 14, 2003.

Weston, Roy F. 1994. *Installation restoration program, draft final record of decision for remedial action at zone 4, Pease Air Force Base, New Hampshire*. Roy F. Weston Inc. West Chester, PA.

Weston, Roy F. 1993. *Pease Air Force Base zone 3 remedial investigation report final draft*. Pease Air Force Base, Portsmouth, New Hampshire. Roy F. Weston, Inc. West Chester, PA.

Weston, Roy F. 1992. *Pease drainage area letter report*. Roy F. Weston Inc. West Chester, PA.

<u>**Appendix**</u>

<u>Disclosure</u>

The purpose of the Appendix is to include pertinent data discussed in the Environmental Quality Characterization Report. In some cases tables and figures may not appear as they would in the original reports. In some cases, the presentation of data was changed to show only sampling sites that are relevant to the Hodgson Brook watershed.

Appendix 1: Hodgson Brook Watershed Boundary

Appendix 2: Hodgson Brook Watershed Impervious Surfaces

Appendix3: Hodgson Brook Watershed Zoning

Appendix 4: Hodgson Brook Watershed Wetlands

Appendix 5: Protected Public Lands/Available Conservation Area

Appendix 6: Pease Development Authority Tenant Lease Agreement

Appendix 7: Hodgson Brook Watershed Prime Wetland Candidates

Appendix 8: Great Bay National Wildlife Refuge Bird Inventory

Appendix 9: Army Corps of Engineers Realignment of Hodgson Brook

Appendix 10: Army Corps of Engineers Reconstruction of Grafton Ditch Design Plan

Appendix 11: Hodgson Brook Buffers

Appendix 12 DES Biomonitoring Project Hodgson Brook Macroinvertebrate Analysis

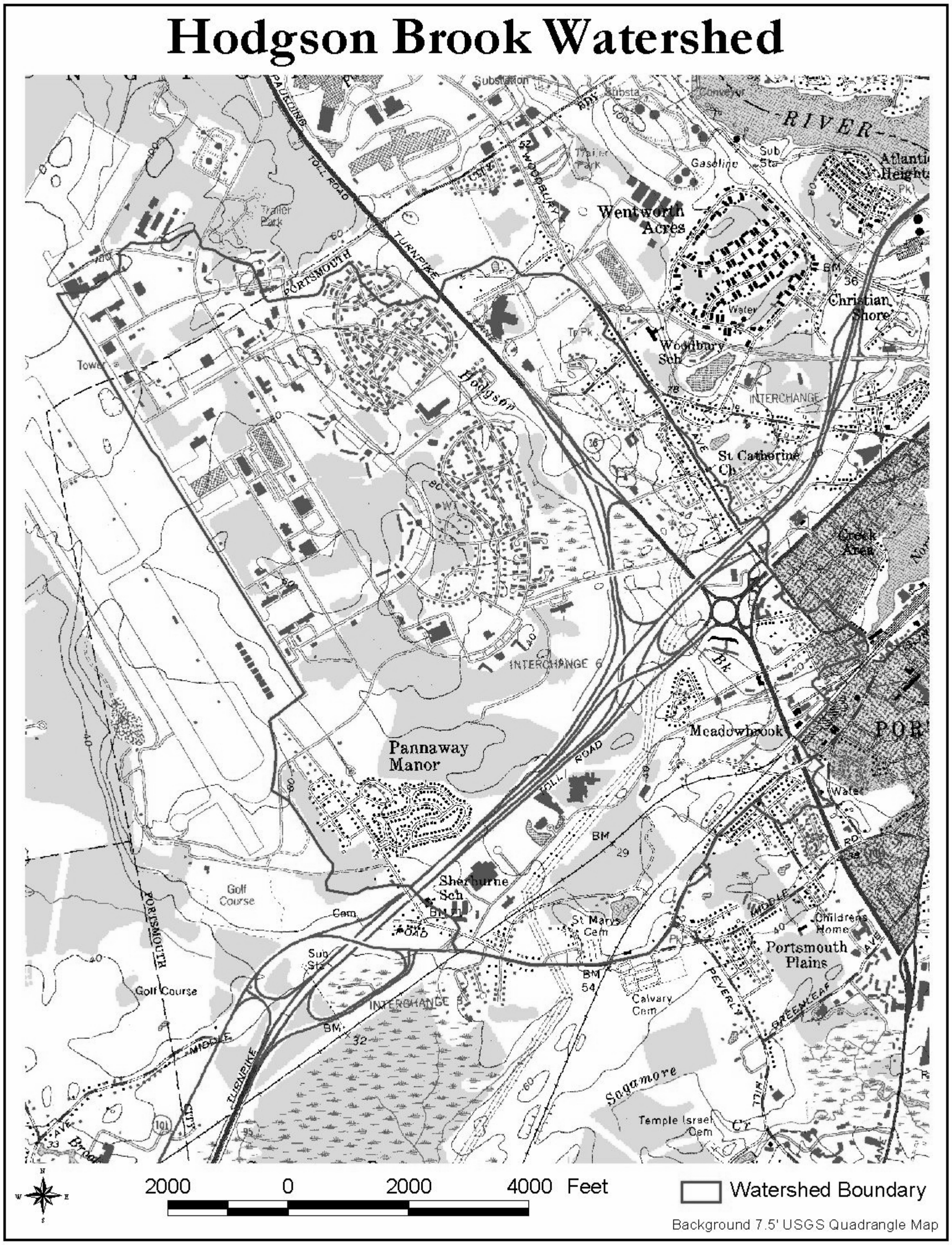
Appendix 13: Hodgson Brook Watershed Storm Drainage Outfalls

Appendix 14: Hodgson Brook Watershed Stormwater Routes

Appendix 15: EPA’s Toxic Waste Inventory for Schiller and Newington Stations, Portsmouth, New Hampshire

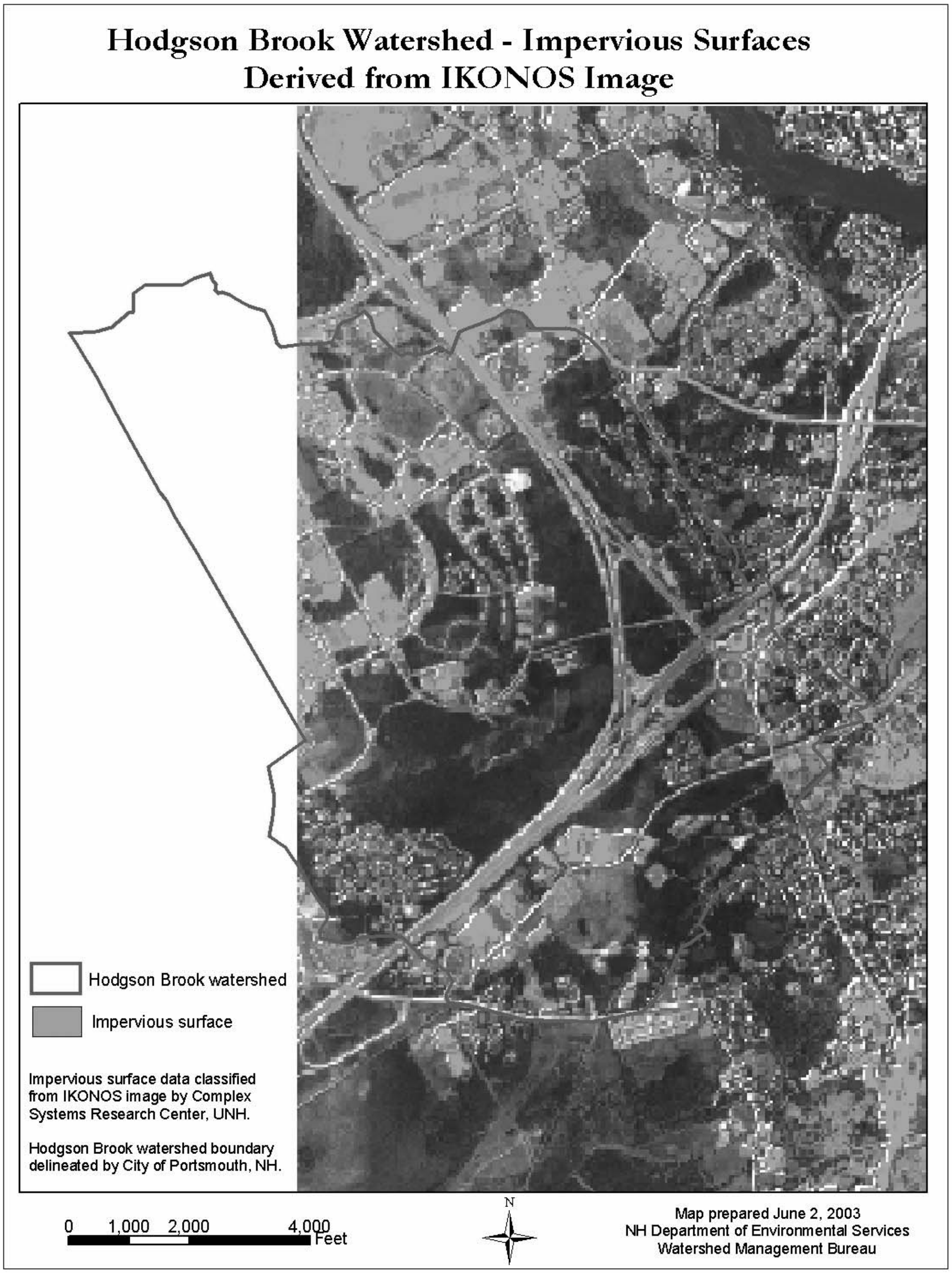
Appendix 16: Environmental Quality Hodgson Brook Watershed Summary Table

Appendix 1: Hodgson Brook Watershed Boundary



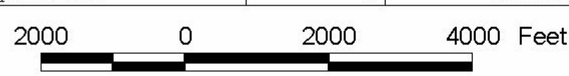
Data Source- Topographic/field interpretation of watershed boundary as determined by Hodgson Brook LAC
Prepared by- Digital Map by Peter Britz, Background information by Steve Miller, Danielle Morin and Jason Wise
Date- May 21, 2003

Appendix 2: Hodgson Brook Watershed Impervious Surfaces



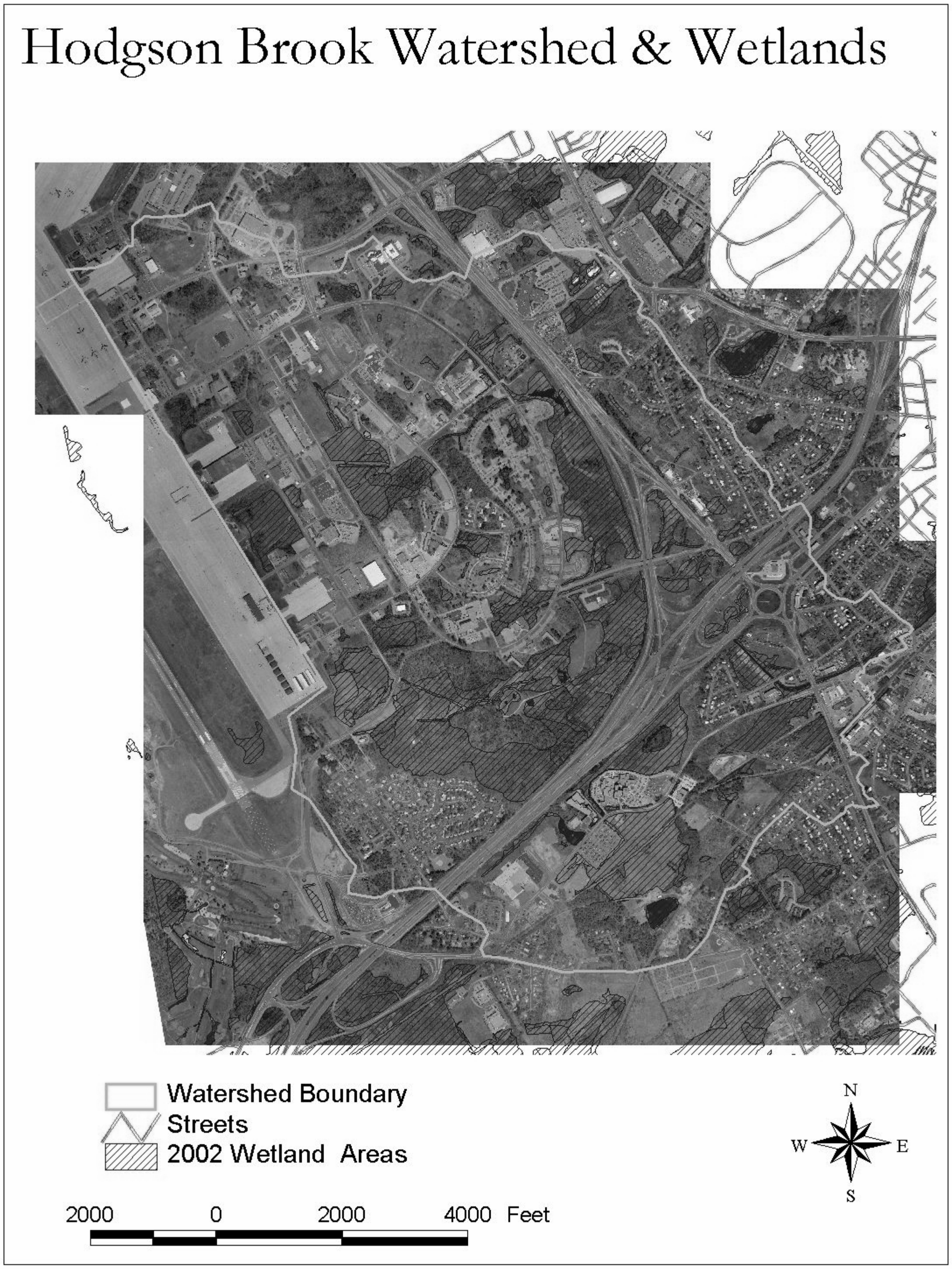
Appendix 3: Hodgson Brook Watershed Zoning

Zonelong	Count	Sum_Acres
Airport	1	65.4000
Airport Business Comme	9	428.1000
Airport Industrial	7	176.4000
Business	2	0.7000
General Business	36	91.7000
General Residence A	71	19.0000
Industrial	7	36.6000
Mixed Residential Busi	6	1.8000
Municipal	14	72.6000
Natural Resource Prote	5	254.4000
Office Research	36	184.1000
Pease Industrial	6	213.8000
Single Residence B	570	230.1000
Unspecified	1	1.0000



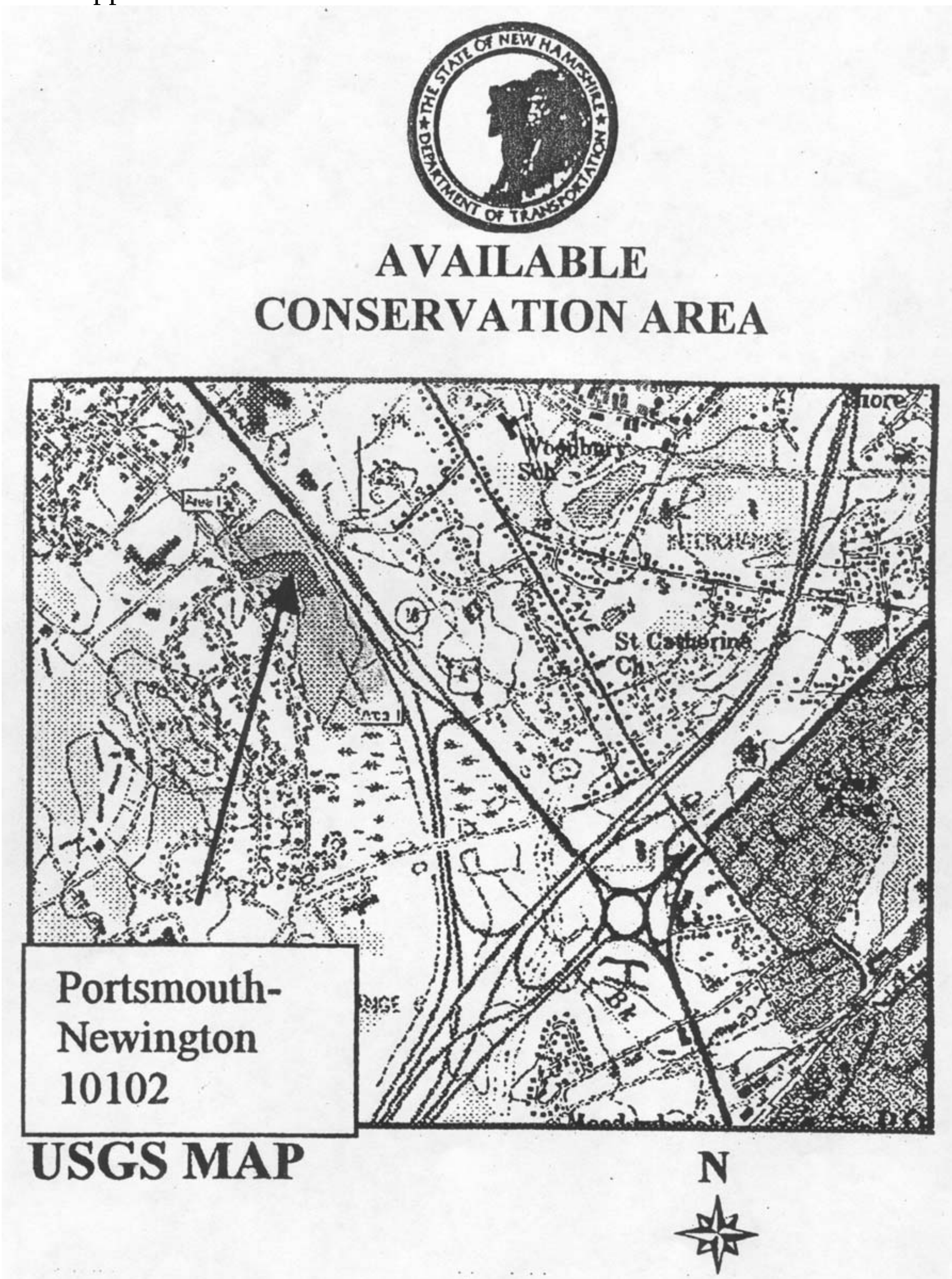
Data Source- City of Portsmouth zoning from Parcel Data, streams and watershed boundary from LAC Digitizing
Prepared by- Peter Britz
Date- May 21, 2003

Appendix 4: Hodgson Brook Watershed Wetlands

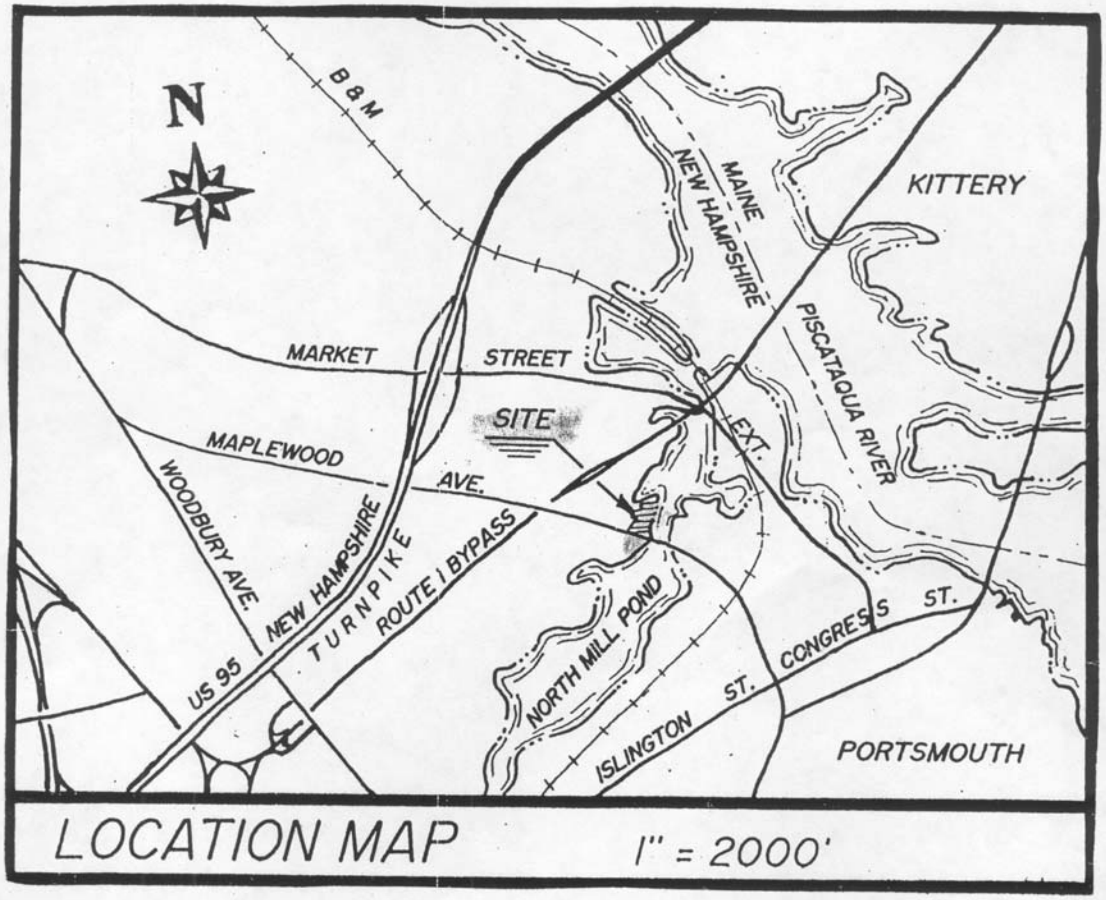


Data Source- May 2000 City of Portsmouth Orthophoto provided by AT&T background with watershed boundary as determined by Hodgson Brook Watershed LAC
Prepared by- Peter Britz
Date- May 21, 2003

Appendix 5: Protected Public Lands/Available Conservation Area



AVAILABLE CONSERVATION AREA



Data Source- Seacoast Land Trust
Prepared by- Danna Truslow
Date- March 24, 2003

Appendix 6: Pease Development Authority Tenant Lease Agreement

Environmental Protection:

10.1 The Lessee and any sublessee or licensee shall comply with the applicable environmental laws and regulations set out in Exhibit G, and all other Federal, state, and local laws, regulations, and standards that are or may become applicable to Lessee's activities on the Leased Premises.

10.2 The Lessee and any sublessee or licensee shall be solely responsible for obtaining at its cost and expense any environmental permits required for its operations under the Lease, independent of any existing Pease Air Force Base permits.

10.3 The Lessee and any sublessee or licensee shall indemnify and hold harmless the Government from any costs, expenses, liabilities, fines, or penalties resulting from discharges, emissions, spills, storage, disposal, or any other action by the Lessee giving rise to Government liability, civil or criminal, or responsibility under Federal, State, or local environmental law. This provision shall survive the expiration or termination of the Lease, and the Lessee's and any sublessee's or licensee's obligation hereunder shall apply whenever the Government incure costs or liabilities for the Lessee's or any sublessee's or licensee's actions giving rise to liability under this condition 10.

10.4 The Government's rights under this Lease specifically include the right for the Air Force officials to inspect upon reasonable notice the Licensed Premises for compliance with environmental, safety, and occupational health laws and regulations, whether or not the Government is responsible for enforcing them. Such inspections are without prejudice to the right of duly constitiuted enforcement officials to make such inspections.

10.5 Expect as provided in Condition 10.6 below, the Government is not responsible for any removal or containment of asbestos.

10.6 The Government shall be responsible for the removal or containment of friable asbestos existing in the Leased premises, including any building, facility or other improvement on the Leased premises, on the earlier of the first day of the Lessee's occupancy or use of each portion of or such building, facility or other improvements on the Leased premises under any instrument entered into between the parties or the Term Beginning Date. "Occupancy" or "use" shall mean any activity or presence to include preparation and construction in or upon such building, facility or other improvement on the Leased premises. The Government agrees to abate all such existing friable asbestos as provided in this Condition 10.6 and Condition 10.7. below. The Government may choose the most economical means of remediating any friable asbestos, which may include removal and containment. The foregoing agreement does not apply to non-friable asbestos which may be distributed by the Lessee's or any sublessee's or assignee's activities and thereby become friable. Non-friable asbestos which becomes friable through or as a consequence of the Lessee's or any sublessee's or licensee's activities under this Lease will be abated by the Lessee at its sole cost and expense.

10.7 Notwithstanding any other provision of the Lease, the Lessee and its sublessee and licensee do not assume any liability or responsibility for environmental impacts and damage caused by the use by the Government, including any agency or agent thereof "toxic substances" or "hazardous wastes", "hazardous substances" or "hazardous materials" or "oil" or "petroleum products" as such terms are defined by applicable law, on any portion of Pease AFB. The lessee and its sublessee and licensees have no obligation to the AF to undertake the defense, remediation and cleanup (including the liability and responsibility for the costs of damage, penalties, or legal and investigative services) solely arising out of any claim or action in existence now, or which may be brought in the future by third parties or any government body against the Government, because of any use of, or release from, any portion of Pease AFB, including any portion of or any building, facility or other improvements on the Leased Premises, of any “toxic substances” or, “hazardous wastes”, “hazardous substances” or “hazardous materials” or “oil” or “petroleum products” prior to the earlier of the first day of Lessee’s occupancy or use of each such portion of or such building, facility or other improvement on the Leased premises under any instrument entered into between the Parties or the Term Beginning date. “Occupancy” or “use” shall mean any activity or presence in or upon such portion of, or such building, facility or other improvement on the Leased premises. Furthermore, the AF recognizes and acknowledges its obligation to indemnify the Lessee and any sublessee to the extent required by the provisions of Public Law No. 101-519, Section s056. This condition 10.7 shall survive the expiration or termination of the Lease.

10.8 The Government acknowledges that Pease AFB has been identified as a National Priority List site under the Comprehensive Environmental Response Compensation and Liability Act of 1980, as amended. The Lessee acknowledges that the Government has provided it with a copy of the Pease AFB Federal Facility Agreement entered into by EPA Region I, the State of NH, and the AF and effective on April 24, 1991, and will provide the Lessee with a copy of any amendments thereto. The Lessee agrees that should any conflict arise between the terms of such agreements as it presently exists or may be amended and the provisions of this Lease, the terms of the FFA will take precedence. The Lessee further agrees that notwithstanding any other provision of the Lease, the Government assumes no liability to the Lessee or its sublessees or licensees should implementation of the FFA interface with the Lessee’s or any sublessee or licensee use of the Leased premises. The Lessee shall have no claim of the account of any such interference against the US or any other officer, agent, employee or contractor thereof, other than for abatement of rent.

10.9 The AF, the US EPA, and DES and their officers, agents, employees, contractors, and subcontractors have the right upon reasonable notice to the Lessee and any sublessee or licensee to enter upon the Leased Premises for the purpose enumerated in this subparagraph and for such other purposes consistent with any provision of the FFA:
(1) to conduct investigations and surveys, including, where necessary, drilling, testpitting, testing soil borings and other activities related to the Pease AFB IRP or the FFA;
(2) to inspect field activities of the AF and its contractors and subcontractors in implementing the Pease AFB IRP or FFA;
(3) to conduct any test or survey required by the EPA or DES relating to the implementation of the FFA or environmental conditions at the leased premises or to verify any data submitted to the EPA or NHDED by the AF relating to such conditions;
(4) to construct, operate, maintain or undertake any other response or remedial action as required or necessary under the Pease AFB IRP or the FFA, including but not limited to monitoring wells, pumping wells and treatment facilites.

10.10 The Lessee agrees to comply with the provisions of any health or safety plan in effect under the IRP or FFA during the course of any of the above described responses or remedial actions. Any inspection, survey, investigation, or other response or remedial action will, to the extent practicable, be coordinated with representative designated by the Lessee and any sublessee or licensee. The Lessee and any sublessee or licensee shall have no claim on account of such entries against the US or any officer, agent, employee, contractor, or subcontractor thereof.

10.11 The Lessee further agrees that in the event of any assignment, sublease or license of the Leased premises pursuant to Condition 20 of the Lease, it shall provide to the EPA and DES by certified mail a copy of the agreement of assignment, sublease or license of the leased premises within 14 days after the effective date of such transaction. The Lessee may delete the financial terms and any other proprietary information from the coy of any agreement of assignment, sublease or license furnished pursuant to this condition 10.11.

10.12 Pease AFB air emissions offsets will not be made available to the Lessee. The Lessee shall be responsible for obtaining from some other source any air pollution credits that may be required to offset emission resulting from its activities under the lease.

10.13 The Lessee shall strictly comply with the hazardous waste permit requirements under Resource Conservation and Recovery Act. The Lessee must provide at its own expense such hazardous waste storage facilities, complying with all laws and regulations, as it may need for storage. Government hazardous waste storage facilities will not be available to the Lessee. Any violation of the requirements of this conditions shall be deemed a breach of the lease.

10.14 Air Force accumulation points for hazardous and other wastes will not be used by the Lessee. Neither will the Lessee permit its hazardous wastes to be commingled with hazardous wastes of the USAF.

10.15 The Lessee shall have a completed and approved plan for responding to hazardous wastes, fuel, and other chemical spills prior to commencement of operations on the leased premises. Such plan shall be independent of the Pease AFB and except for initial fire response and or spill containment, shall not rely on use of Pease AFB personnel equipment. Should the Government provide any personnel or equipment, whether for initial fire response and/or spill containment, otherwise on request of the Lessee, or because the Lessee was not in the opinion of the said officer conducting timely cleanup actions, the Lessee agrees to reimburse the Government for its costs.

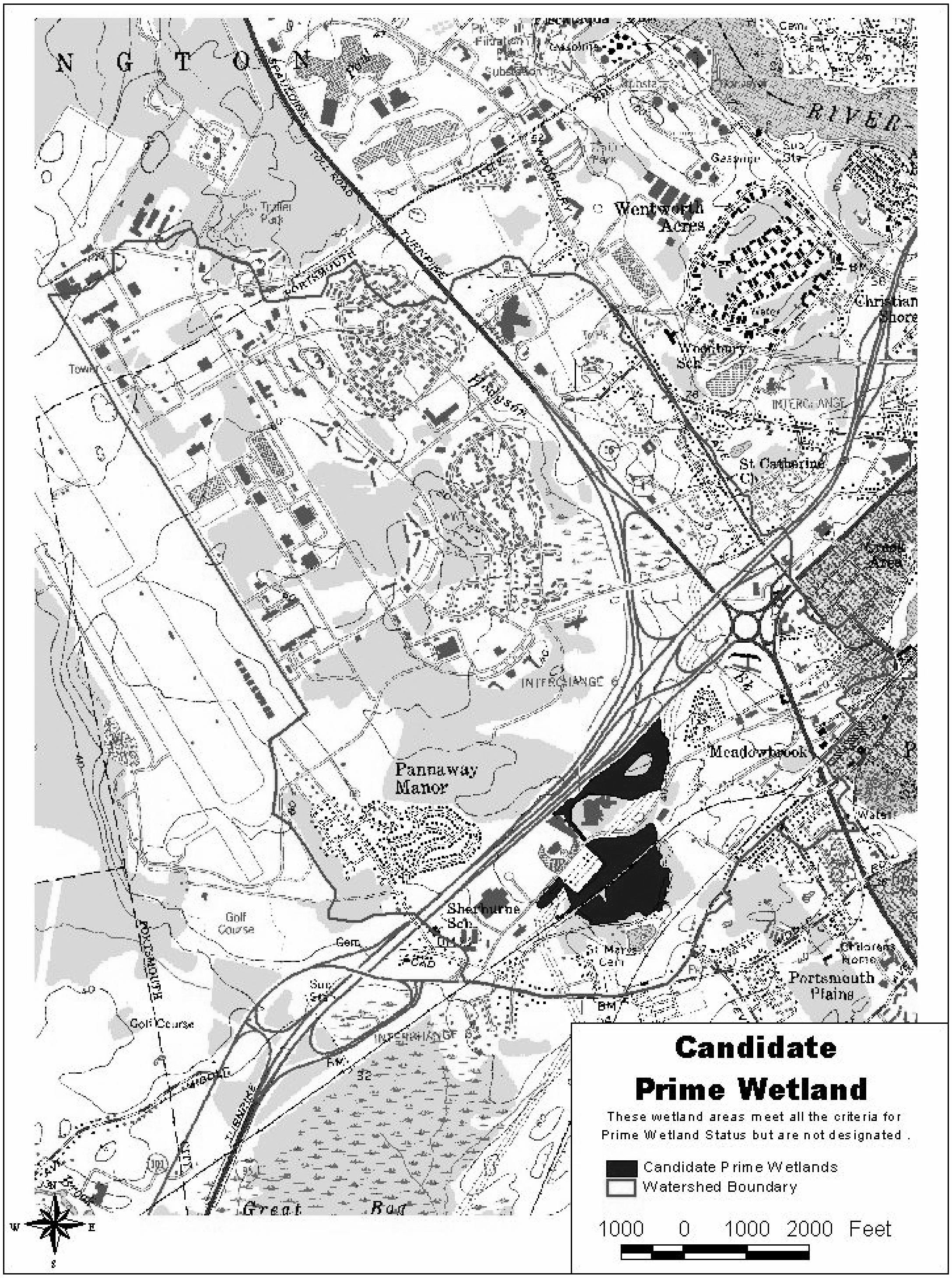
10.16 The Lessee further agrees that it shall provide, or shall require its sublessee or licensee to provide the Air Force, EPA, and DES with prior written notice accompanied by a detailed description of all plans for any Alterations which may impede or impair any activities under the FFA or are to be undertaken in certain areas of the Airport identified as “Areas of Special Notice” on Exhibit I-2 hereto. (These Areas of Special Notice consist of either “operable units” as defined in the National Contingency Plan) or “Areas of Concern” (as defined in the FFA) and include buffer areas as shown in Exhibit I-2. The notice and accompanying plans shall be provided to the Air Force, EPA and DES sixty days in advance of the commencement of any such Alterations. The detailed description of said plans shall include a description of the effect such planned work may have with respect to site soil and groundwater conditions and the cleanup efforts contemplated under the FFA. Notwithstanding the preceding three sentences, the Lessee or its sublessee shall be under no obligation to provide advance written notice of any Alterations that will be undertaken totally within any structure located on the Leased premises, provided that such work will not impede or impair any activities under the FFA. However, any work below the floor of any such structure that will involve excavation in and/or disturbance of disturbance of concrete flooring, soil, and/or groundwater will be subject to the 60 days notice requirement imposed by this condition.

10.17 Notwithstanding any other provision of the Lease, the Lessee agrees it shall coordinate all Alterations and any other work subject to the notice requirement imposed by Condition 10.16

above with USAF, EPA and DES in accordance with the FFA and in a manner that does not impede or impair any activities under the FFA or exacerbate then existing conditions.

Data Source- Jerry Dexter, PDA
Date- March, 2003

Appendix 7: Hodgson Brook Watershed Prime Wetland Candidates



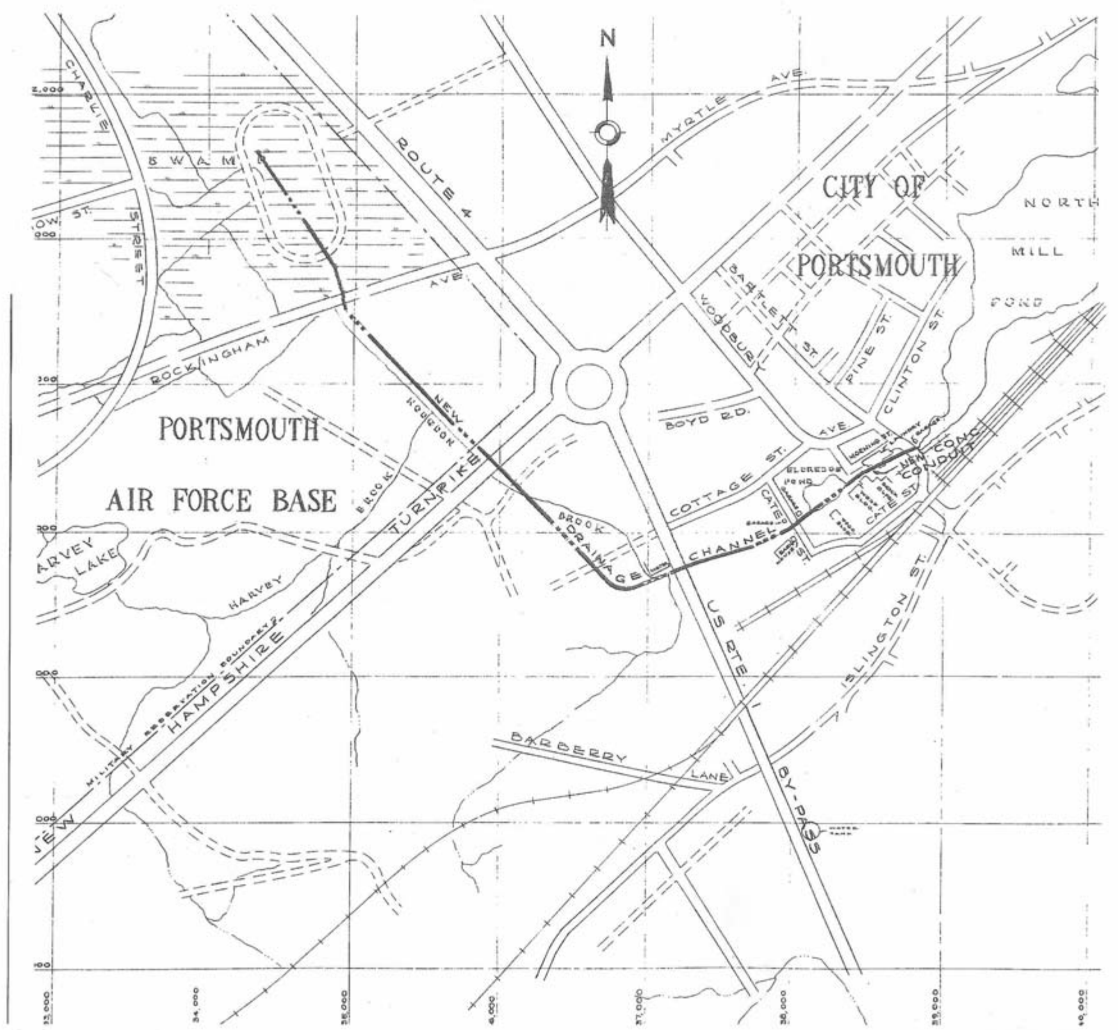
Data Source- City of Portsmouth 2002 wetland inventory
Prepared by- Peter Britz
Date- June 6, 2003

Appendix 8: Great Bay National Wildlife Refuge Bird Inventory

Bird Species Inventory (April 20, 1995)		
Pied-billed grebe (Podilymbus podiceps)	American woodcock (Philohela minor)	Balck and white warbler (Miniotilta varia)
Double crested cormorant (Phalacrocorax auritus)	Ring billed gull (Larus delawarensis)	Blue winged warbler (Vermivora pinus)
American bittern (Boteurus lentiginosus)	Herring gull (Larus argentatus)	Yellow warbler (Dendroica perchia)
Great blue heron (Ardea herodias)	Great black backed gull (Larus marinus)	Chestnut sided warbler (Dendroica coronate)
Great egret (Egretta thula)	Common tern (Sterna hirundo)	Pine warbler (Dendroica pinus)
Green- backed heron (Butorides striatus)	Mourning dove (Zenaida macroura)	Prairie warbler (Dendroica discolor)
Mute swan (Cygnus olor)	Black billed cuckoo (Coccyzus erythropthalmus)	Palm warbler (Dendroica palmarum)
Canada goose (Branta Canadensis)	Great horned owl (Bubo virginianus)	Ovenbird (Seiurus aurocapillus)
Wood duck (Aix sponsa)	Chimney swift (Chaetura pelagica)	Northern waterthrush (Seiurus noveboracensis)
Green winged teal (Anas rubripes)	Belted kingfisher (Megaceryle alcyon)	Mourning warbler (Oporornis philledelphia)
American black duck (Anas rubripes)	Downy woodpecker (Picoidas pubescens)	Common yellowthroat (Geothipis trichas)
Mallard (Anas platyrhynchos)	Hairy woodpecker (Picoides villosus)	American redstart (Setophaga ruricilla)
Northern pintail (Anas acuta)	Northern flicker (Colaptes auratus)	Scarlet tanager (Piranga olivacsa)
Gadwall (Anas strepera)	Eastern wood pewee (Contopus virens)	Northern cardinal (Cardinalis cardinalis)
American wigeon (Anas americana)	Yellow bellied flycatcher (Empidonax flaviventris)	Indigo bunting (Passerina cyanea)
Ring necked duck (Aythya collaris)	Willow flycatcher (Empidonax flaviventris)	Rufous sided towhee (Pipilo erythropthalmus)
Greater scaup (Aythya marlla)	Eastern phoebe (Sayornis phoebe)	Savannah sparrow (Passerculus sandwichensis)
Lesser scaup (Aythya affinis)	Great crested flycatcher (Myierchus crinitus)	Vesper sparrow (Pooecetes gramineus)
Common goldeneye (Bucephala ciangula)	Eastern kingbird (Tyrannus tyrannus)	Dark eyed junco (Junco hyemalis)
Bufflehead (Bucephala albeoia)	Tree swallow (lridoprocne bicolor)	American tree sparrow (Spizella arborea)
Hooded merganser (Lophodytee cucullatus)	Barn swallow (Hirundo rustica)	Chipping sparrow (Spizella passerina)
Common merganser (Mergus merganser)	Blue jay (Cyanocitta cristara)	Field sparrow (Spizella pusilla)
Red-breasted merganser (Mergus serrator)	American crow (Corvus brachyrhunchos)	Song sparrow (Melospiza melodia)
Turkey vulture (Cathactes sura)	Balck capped chickadee (Parus atricapillus)	Bobolink (Dollchonyx oryzivorus)
Osprey (Pandion hallaetus)	Tufted tltmouse (Parus bicolor)	Eastern meadowlark (Sturnella magna)
Bald eagle (Haliaeetus leucocephalus)	Red breasted nuthatch (Sitta canadensis)	Red winged blackbird (Agelaius phoeniceus)
Northern harrier (Circus cvaneus)	White breasted nuthatch (Sitta parollnensia)	Northern oriole (Lcterus galbula)
Sharp shinned hawk (Accipiter striatus)	Brown creeper (Certhla famillaris)	Rusty blackbird (Euphagus carolinus)
Cooper’s hawk (Accipiter cooperii)	House wren (Troglodytes aedon)	Common grackle (Ouiscalus guiscula)
Red shoulder hawk (Butao lineatus)	Northern mockingbird (Mimus polyglottos)	Brown headed cowbird (Molothrus arer)
Broad winged hawk (Buteo platypterus)	Gray catbird (Dumatella carolinensia)	Rose breasted grosbeak (Pheuctidus ludovicianus)
Red talled hawk (Bureo lamaicansis)	Brown thrasher (Toxostoma rufum)	Purple finch (Carpodacus purpureus)
American kestrel (Falco sparverius)	American robin (Turdus migratorius)	House finsch (Carpodacus mexicanus)
Peregrine faloon (Falco peregrinus)	Wood thrush (Hylocichia mustelina)	American goldfinch (Carpodacus tristis)
Ruffed grouse (Bonasa umbellus)	Veery (Catharus fuscescens)	
Wild turkey (Maleagris gallopavo)	Eastern bluebird (Sialla sialls)	
American coot (Fulica americana)	Ruby crowned kinglet (Regulus calendula)	
Killdeer (Charadrius vociferous)	Cedar waxwing (Bombycilla cedrorum)	
Greater yellowlegs (Tringa melanoleuca)	European starling (Sturnus vislgaris)	
Lesser yellowlegs (Tringa flavlpes)	Red eyed vireo (Vireo olivaceus)	
Solitary sandpiper (Tringa solitaria)	White eyed vireo (Vireo griseus)	
Spotted sandpiper (Actitis macularia)	Watching vireo (Vireo gllvus)	
Least sandpiper (Calidris minutilla)		

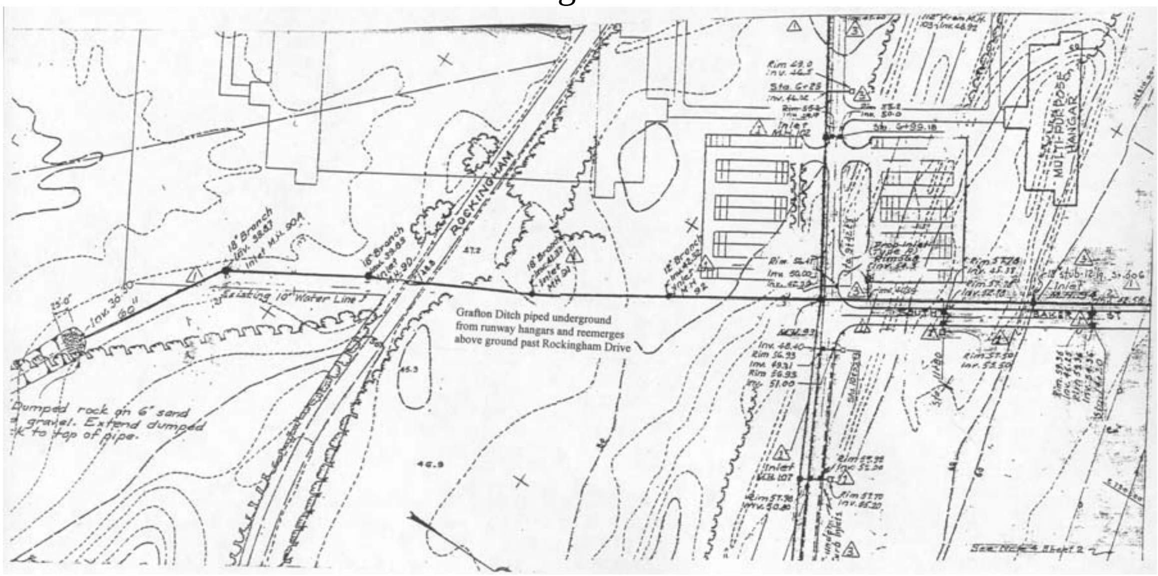
Source: Great Bay National Wildlife Refuge Pease International Tradeport Portsmouth, NH

Appendix 9: Army Corps of Engineers Realignment of Hodgson Brook



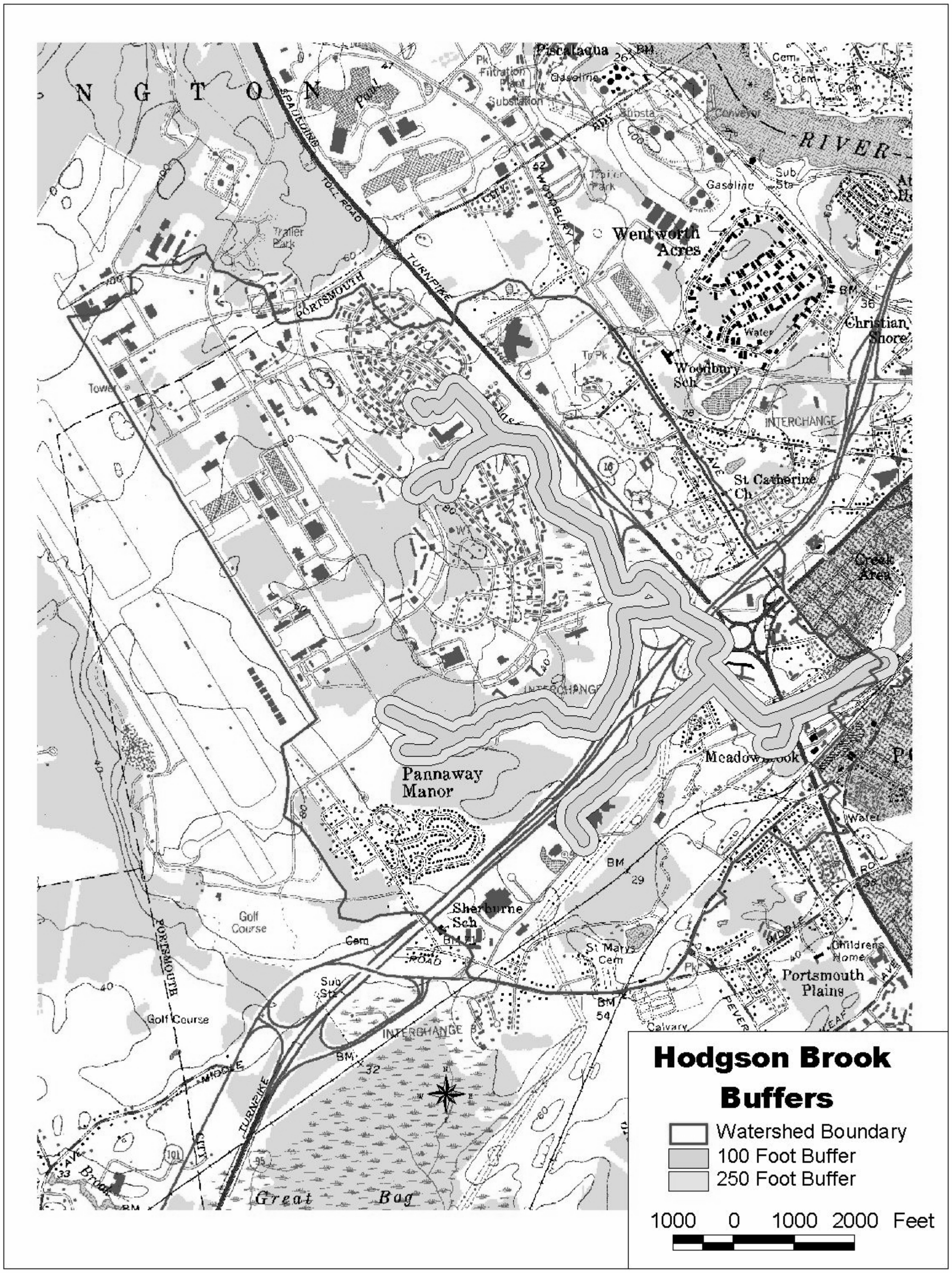
Prepared by- US Army Corps of Engineers New England Division
Date- September, 1956

Appendix 10: Army Corps of Engineers Reconstruction of Grafton Ditch Design Plan



Prepared by- US Army Corps of Engineers New England Division
Date- September, 1956

Appendix 11: Hodgson Brook Buffers



Data Source: Hodgson Brook LAC digitized streams and USGS 7.5 min. quadrangle
Prepared by- Peter Britz
Date- May 21, 2003

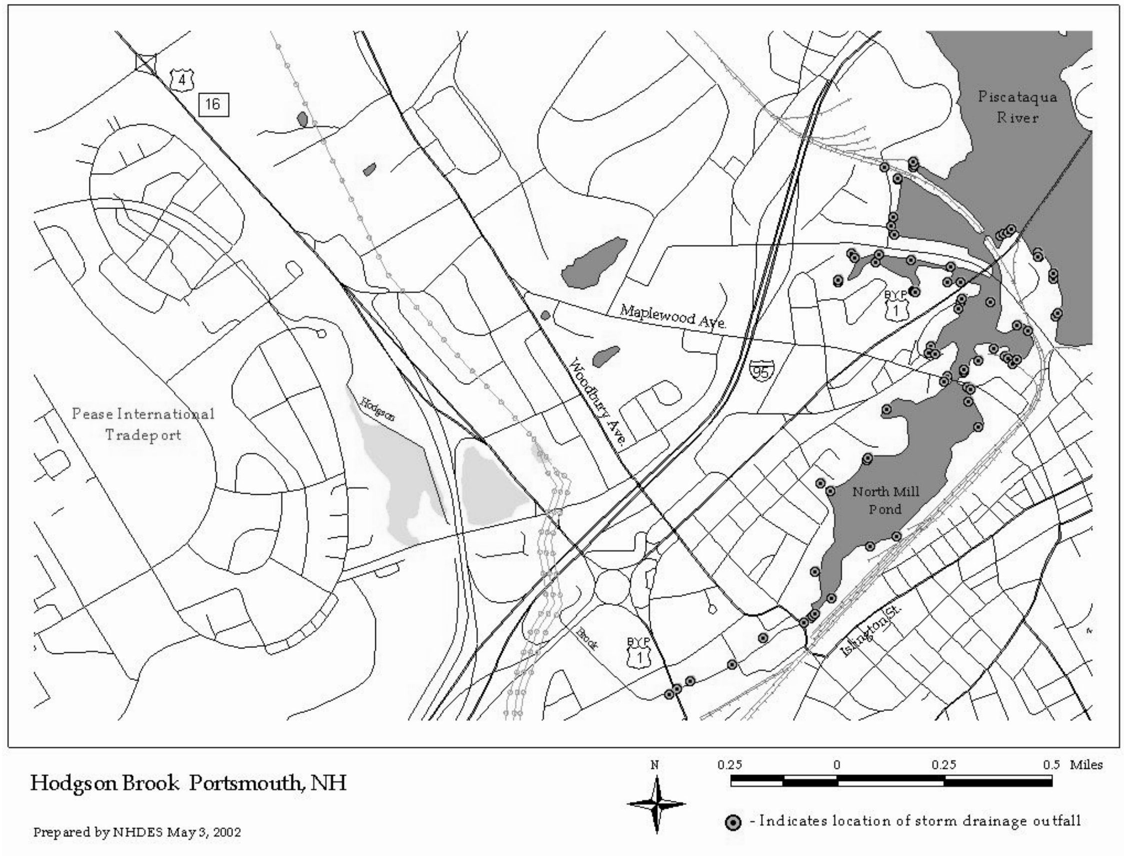
Appendix 12: DES Biomonitoring Project Hodgson Brook Macroinvertebrate Analysis

RepNum	CollMeth	FinalID	Individuals	Stage
1	AS	Hydropsyche	17	larval
1	AS	Turbellaria	4	larval
1	AS	Sphaeriidae	3	larval
1	AS	Planorbidae	9	larval
1	AS	Ancylidae	12	larval
1	AS	Hydropsychidae	17	larval
1	AS	Hirudinea	1	larval
1	AS	Hemerodromia	4	larval
1	AS	Gastropoda	21	larval
1	AS	Chironomidae	9	larval
1	AS	Chimarra	25	larval
1	AS	Cheumatopsyche	48	larval
1	AS	Caecidotea	65	larval
1	AS	Boyeria	1	larval
1	AS	Physa	12	larval
2	AS	Hydropsyche	34	larval
2	AS	Caecidotea	47	larval
2	AS	Cheumatopsyche	119	larval
2	AS	Chimarra	44	larval
2	AS	Chironomidae	9	larval
2	AS	Physa	14	larval
2	AS	Simulium	6	larval
2	AS	Turbellaria	40	larval
2	AS	Hirudinea	2	larval
2	AS	Gastropoda	9	larval
3	AS	Ferrissia	17	larval
3	AS	Sphaeriidae	9	larval
3	AS	Planorbidae	11	larval
3	AS	Physidae	9	larval
3	AS	Physa	17	larval
3	AS	Oligochaeta	2	larval
3	AS	Mystacides	1	larval
3	AS	Hydropsychidae	3	larval
3	AS	Hydropsyche	5	larval
3	AS	Hemerodromia	1	larval
3	AS	Chironomidae	6	larval
3	AS	Chimarra	9	larval
3	AS	Cheumatopsyche	35	larval
3	AS	Caecidotea	57	larval
3	AS	Turbellaria	52	larval
3	AS	Hirudinea	1	larval

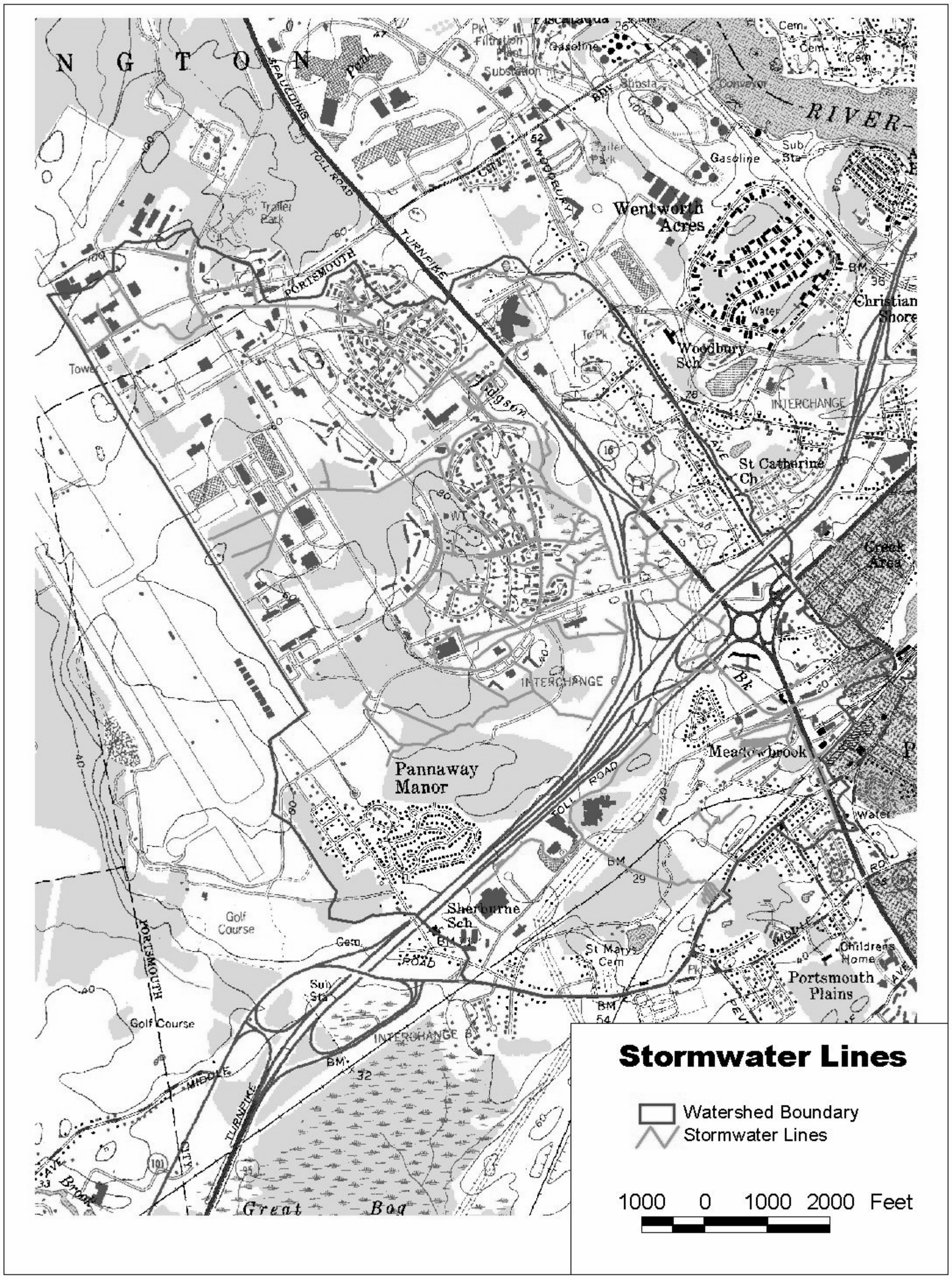
*AS = artificial substrate (rock baskets)

Source: New Hampshire Department of Environmental Services (DES). Unpublished. 2000 Hodgson Brook Biomonitoring Project. Portsmouth, NH.

Appendix 13: Hodgson Brook Watershed Storm Drainage Outfalls



Appendix 14: Hodgson Book Watershed Stormwater Routes



Data Source- City of Portsmouth Stormwater mapping data. Hodgson Brook LAC Watershed Boundary, USGS 7.5 min. quad background
Prepared by- Peter Britz
Date- May 21, 2003

Appendix 15: EPA's Toxic Waste Inventory for Schiller and Newington Stations, Portsmouth, New Hampshire

Newington Station Total Air Emissions (lbs/yr)

Reported Releases	1998	1999	2000
Arsenic	424	-	-
Mercury	-	-	40
Vanadium	-	-	100
Hydrochloric Acid	32,000	34,000	11,000
Lead	497	-	-
Sulfuric Acid	160,000	170,000	53,000

Reported TRI Waste Managed Total (2000) = 73,546 lbs.

Newington Station

Respiratory Pollutants (tons/yr)	1998
Nitrogen Oxides	1299
Sulfur Dioxides	13095
Particulates	172

Schiller Station Total Air Emissions (lbs/yr)

Reported Releases	1998	1999	2000
Arsenic	107	-	-
Mercury	681	-	50
Vanadium	-	-	490
Hydrochloric Acid	540,000	220,000	300,000

Reported TRI Waste Managed Total (2000) = 503,317lbs.

Schiller Station

Respiratory Pollutants (tons/yr)	1998
Nitrogen Oxides	1926
Sulfur Dioxides	4708
Particulates	72

Source: http://www.epa.gov/tri

Appendix 16: Environmental Quality Hodgson Brook Watershed Summary Table

Pollution Issue	Threat	Status and Trends	Sources	Impacts
Bacteria	Diseases to humans who come in contact with water or shellfish contaminated areas	Highest annual geomean in entire GBCW network in 97, 99, 00, 01 but bacterial concentrations have been decreasing each year*Bartlett St has highest F.C. data of all GBCW sites*UNH study found Bartlett St to have highest F.C. data	Stormwater runoff, impervious surfaces, storm drains, WWTF, pet waste, birds and wildlife	State swimming standards exceeded in NMP*Mussels in NMP had F.C. which exceeded FDA guidelines*NMP is closed to shellfish harvesting
Toxics	Toxic substances can produce adverse physiological effects on aquatic organisms*Biomagnification	Data are limited in watershed*Gulfwatch study found highest concentrations of organic contaminants in NMP*Mercury is only metal to exceed toxic guidelines at 1 of 11 sampling sites (Bartlett St)*Decreasing PAH trend since 98 in Lower Grafton Ditch sediments*2001 toxic chemicals detected in sediments of Lower Grafton Ditch but only arsenic and lead exceeded state standards	Pease International Tradeport, atmospheric deposition, stormwater runoff, illicit discharge into stormdrains, runoff from industrial/commercial areas, households	Freshwater fish consumptionadvisory based on mercury*ocean fish and shellfish consumption based on PCBs and mercury*lobster normality consumptionbased on PCBs and dioxins
Nutrients	Increased incidences of phytoplankton blooms*Increased invasive species*Decreased DO in water column	Limited data is available for watershed*UNH study found increased levels of nitrate, ammonium, phosphate concentrations at Bartlett St*First incident of instantenous DO measurement <75% at Bartlett St	Excess nutrient input from anthropogenic sources, fertilizers, WWTF, stormwater runoff, atmospheric deposition, grey water	Less O_2 available in water column to break down bacteria*Change of aquatic plant and organisms that can survive under conditions
Sediments	Sediments act as vectors for microbes, reservoirs for pollutants, movement of soil to water column	Limited data is available for watershed*2 site specific/alteration of terrain oermit violations in Pease on March 12, 2001 at Flextronics and April 1, 2003 at Liberty Mutual Ins.	Runoff, discharge from drains, movement of disturbed sites such as those under development, impervious surfaces, road sanding	Potential to smother habitats for fish eggs, aquatic biota, vegetation, pass contaminants through food web, contaminant vector, increased turbidity, light limitation
Solidwaste	Degrade natural habitat, asthetic	Annual NMP cleanups remove trash from banks of Pond, although dumping is continuing	Litter, illegal dumping, dumpsters, yard waste, trash	Asthetic*Degrade natural habitat for animals and aquatic organisms